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A PROGRESS REPORT. ARKANSAS-RED RIVER BASINS WATER QUALITY CONSERVATION PROJECT

PUBLIC HEALTH SERVICE, DALLAS, TEXAS

JUNE 1958

PB 260 167

FINAL REPORT

ARKANSAS-RED RIVER BASINS

WATER QUALITY

CONSERVATION PROJECT

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*Water conservation
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Degradation
Water pollution effects(Materials)
Tables(Data)

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A Progress Report

Arkansas-Red River Basins

Water Quality

Conservation Project

Covering Period July 1, 1957 to March 1, 1958

Prepared by

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service

Region VII

1114 Commerce Street

Dallas, Texas

June, 1958

TABLE OF CONTENTS

	Page
ACKNOWLEDGMENTS	i
SUMMARY	1
INTRODUCTION	3
DISCUSSION	4
Description of Area and Problem	4
Purpose of Project	5
Scope of Project	6
General Observations	11
REFERENCES	12
TABLES (All Tables Follow Pages Indicated.)	
Table I, Reference Location, Arkansas River at Van Buren, Arkansas	11
Table II, Reference Location, Arkansas River at Tulsa, Oklahoma	11
Table III, Reference Location, Canadian River at Whitefield, Oklahoma	11
Table IV, Available Data, Arkansas River Basin	9
Table V, Available Data, Red River Basin	9
PLATES (All Plates Follow Pages Indicated.)	
Plates I, Arkansas-Red River Basins Map	4
Plate II, Location of Continuous Sampling Stations	9
Plate III, Sources of Pollution	5
Plate IV, Cumulative Frequency Distribution Curves (Tulsa, Oklahoma)	10
Plate V, Cumulative Frequency Distribution Curves (Gainesville, Texas)	10
Plate VI, Ark. River Quality and Discharge Profile	10
Plate VII, Red River Quality and Discharge Profile	10

Page

APPENDICES. 13

Appendix I, List of Contributors

Appendix II, List of Continuous Sampling Stations

Appendix III

Terminology

Data Summary Sheets, Arkansas River

Data Summary Sheets, Red River

ACKNOWLEDGMENTS

Many local, State, and Federal governmental agencies; individuals; and representatives of industry, concerned with water pollution control and water resources development have assisted in the Project by providing basic data, technical advice, and other information. These valuable contributions are acknowledged with appreciation. A list of contributors is given in Appendix I.

ARKANSAS-RED RIVER BASINS
WATER QUALITY CONSERVATION PROJECT

SUMMARY

The Arkansas-Red River Basins Water Quality Conservation Project was initiated by the Public Health Service to determine factors which cause mineral degradation of the waters of the Arkansas and Red Rivers, the location and amount of waters of varying quality suitable for beneficial use, and methods or measures for the improvement of the over-all water quality. The material assembled and evaluated to March 1, 1958 is provided in this report to furnish a ready reference to those agencies and others having an urgent need for it.

The project is divided into four phases. Phase I, to be completed June 30, 1958, comprises the assembly and partial analysis of all known data and information on water quality in the two basins. Phase II includes the field studies necessary to clearly define the sources of pollution and to supplement existing data, and is programmed for completion by June 30, 1960. Phase III will include the determination of the practicability and economic feasibility of possible control measures and the preparation of a final report. This portion of the project is scheduled to be completed June 30, 1961. Phase IV will be the implementation of the conclusions reached in the course of the project study. This phase is not considered a Public Health Service function but rather the function of local, State, Federal, or other construction agencies.

The project encompasses the Arkansas River and its tributaries between Little Rock, Arkansas, and Great Bend, Kansas, and all of the Red River System above Shreveport, Louisiana. The project area is approximately 184,000 square miles lying in Arkansas, Kansas, Louisiana, New Mexico, Oklahoma, and Texas. It is within this area that the principal problems of mineral pollution occur.

Study efforts have been directed toward the collection and evaluation of all known documented data and information concerning mineral quality of water in the basins. The greatest volume of data has been secured from sampling stations operated continuously over long periods of time by the U. S. Geological Survey and its cooperating agencies. Water quality data representing a total of 290 station years from 80 continuous sampling stations, together with corresponding discharge data, have been tabulated for evaluation purposes.

Monthly and annual summaries showing average quantities in tons per day and weighted average concentrations in parts per million of chlorides, sulfates, and total dissolved solids have been tabulated for each continuous station for the period of record. Tabulations also include maximum and minimum values during the same periods of time.

Cumulative frequency distribution curves have been developed for the Red River at Gainesville, Texas and the Arkansas River at Tulsa, Oklahoma. These curves indicate the yield of water per year for varying concentrations of chlorides, sulfates, and total dissolved solids.

Mineral loadings on the stream have been expressed graphically by means of a quality and quantity profile. A graphic presentation shows conditions in the two stream systems during the critical water year 1955-56.

A frequency distribution analysis shows an average of 200,000 and 250,000 acre-feet respectively each year of relatively good quality water (500 ppm or less dissolved solids) which flow past both the Gainesville and Tulsa Stations. The duration of such runoff is extremely short, making its capture or diversion difficult. The stream profiles give an indication of the mineral and runoff contribution of each stream and are helpful in locating areas where detailed field investigations should be directed.

General observations made thus far include:

1. Additional discharge and quality data, particularly in the Upper Red and Upper Cimarron, North Canadian, and Canadian River watersheds, must be obtained before conclusions can be drawn about the sources and amounts of mineralization contributed by each river and its tributaries.

2. Summary data on some streams indicate substantial increase in total dissolved solids and chloride loads as rivers flow through oil fields without a corresponding increase in sulfates, indicating oil field pollution.

3. Summary data indicate that sizeable quantities of water with a concentration equal to or less than 250 parts per million chloride (Cl^-) are available at Tulsa and Gainesville even during drought periods; however, the good quality water occurs during short periods of time making its capture or diversion difficult.

4. Records of certain streams under study compiled early in the 20th century indicate high quality water. Inadequate early records prevent an over-all comparison of present stream quality with that of 50 years ago.

5. Extensive field investigations will be necessary to pinpoint sources of pollution.

Care should be used in applying conclusions based on the data presented in this report, because of the unknown factors which will not be revealed without further investigation. While the information may be sufficient to guide isolated water resource projects, it is not sufficient to justify basin-wide conclusions as to the location and relative amounts of man-made and natural pollution.

INTRODUCTION

The Public Health Service initiated the Arkansas-Red River Basins Water Quality Conservation Project July 1, 1957 under the Federal Water Pollution Control Act, Public Law 660 (84th Congress).

The Federal Water Pollution Control Act states that "The Surgeon General shall, after careful investigation, and in cooperation with other Federal agencies, with State water pollution control agencies and interstate agencies, and with the municipalities and industries involved, prepare or develop comprehensive programs for eliminating or reducing the pollution of interstate waters and tributaries thereof and improving the sanitary condition of surface and underground waters."

Section 4(a) of the Act also states: "The Surgeon General shall conduct in the Public Health Service and encourage, cooperate with, and render assistance to other appropriate public (whether Federal, State, interstate, or local) authorities, agencies, and institutions, private agencies and institutions, and individuals in the conduct of, and promote the coordination of, research, investigations, experiments, demonstrations, and studies relating to the causes, control, and prevention of water pollution."

The Arkansas and Red River Basins are very similar; rainfall patterns are almost identical. Temperatures are more moderate in the Red River Basin. The geology of the basins is similar; the drainage of both rivers is across the plains region where outcrops of soluble minerals occur. Both basins are underlain with extensive salt deposits and oil reservoirs; both have areas of poor water quality. Because of their physical likeness, and the similarity of the water quality problems and control, the two basins are considered as one unit in this project.

Droughts have periodically plagued both basins. The most recent drought (1952-56) was very severe and brought the problem of water supply and water quality to the attention of both city dwellers and farmers. Water in many streams was too heavily mineralized to use. Hence, poor water quality was recognized as a problem of major proportions. It is now apparent that much of the economy and future development of the area are dependent upon the availability of water adequate in quality and quantity.

The Arkansas-White-Red Basins Inter-Agency Committee Report [1] states that salinity derived from both oil fields and natural sources constitutes the greatest pollution problem in the study area because of its wide distribution, the extent of the damages, and the technical and economic difficulty involved in its abatement.

The importance of water to the future of the area is such that every effort must be exercised to control pollution. The scope of the problem dictates that a considerable resource of technical personnel and money will be needed to develop a comprehensive evaluation of the pollution problem.

DISCUSSION

1. Description of Area and Problem.

The Arkansas and Red River Basins are part of the southwestern and central plains region. They comprise an area of approximately 254,000 square miles, 2/ roughly 10 percent of the United States, and include all or a portion of Arkansas, Colorado, Kansas, Louisiana, Missouri, New Mexico, Oklahoma, and Texas. The basin area includes a variety of geographical land forms, varying from the high, rugged mountains of Colorado which are over 10,000 feet in elevation; across the plains of Kansas, Oklahoma, and Texas; to the low-lying but rugged mountains and hilly terrain in the Ozark-Ouachita uplift; and finally to the near sea level elevations of the coastal and alluvial flood plains where the two rivers approach the Mississippi River through the States of Arkansas and Louisiana. Plate I is a map of the two basins.

The area under study has been limited to the Arkansas River System between Little Rock, Arkansas, and Great Bend, Kansas, and the Red River System above Shreveport, Louisiana; an area of approximately 184,000 square miles. 2/

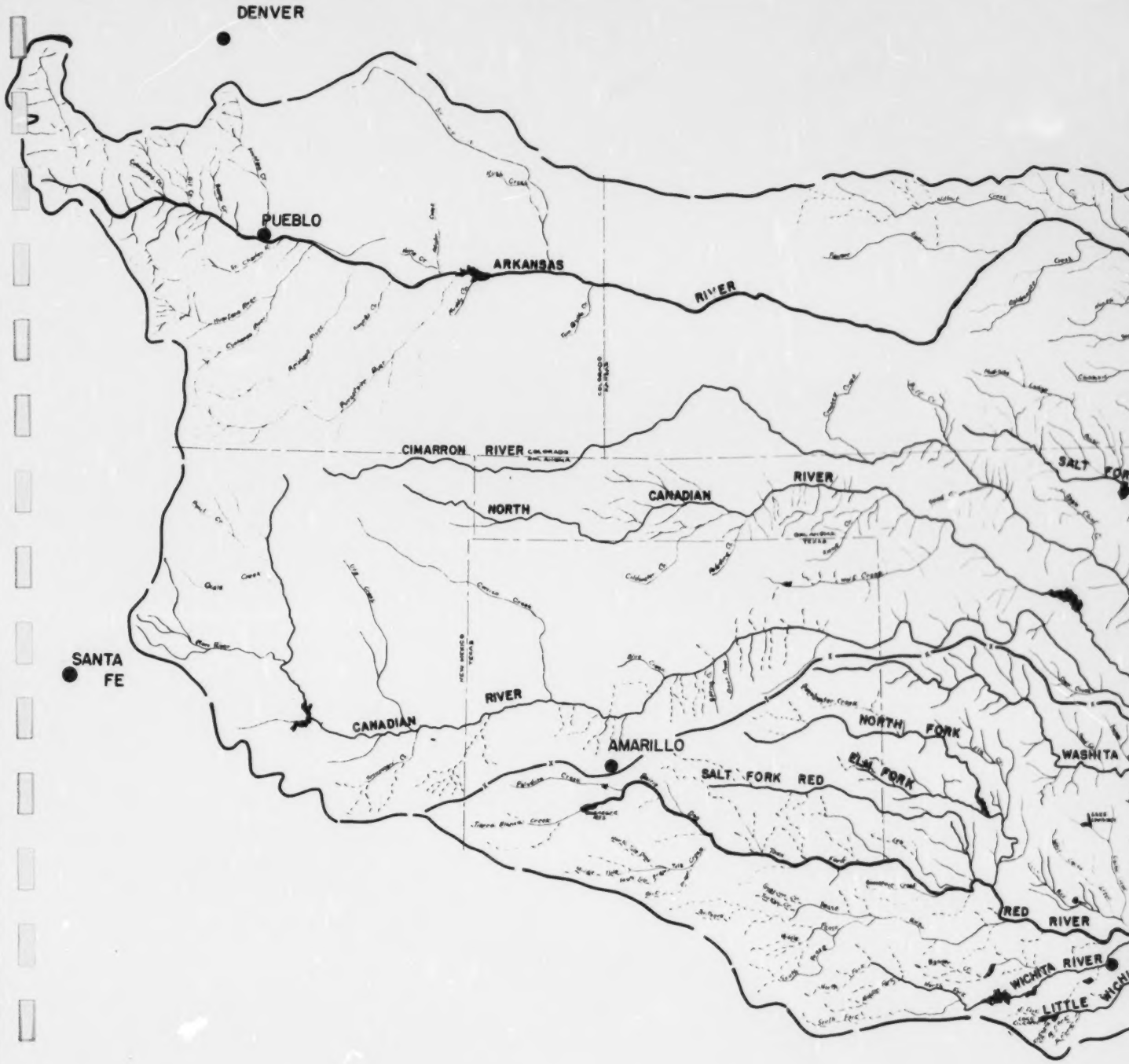
Approximately 3,900,000 people live in the Arkansas River Basin and approximately 2,500,000 in the Red River Basin. Population density in 1950 in the Arkansas River Basin was 23.9 persons per square mile and 27.5 persons per square mile in the Red River Basin. Population growth in these two basins has been slow in recent years, increasing 3.6 percent in the Arkansas River Basin and decreasing 6.0 percent in the Red River Basin during the period 1940-50. During this same period the population of the United States increased 14.5 percent and the population density was 50.4 persons per square mile in 1950. 1/

The retardation of the region's population, industrial, and agricultural growth in comparison to other parts of the country may be associated in part with both the deficiency in water quantity and the lack of water of suitable quality in the basins. The importance of usable water to the region's development cannot be over emphasized.

Agriculture remains the principal source of employment in the basins although the trend appears to be toward fewer farms and declining farm labor requirements. Industries important to the economy of the area include petroleum, chemical, petrochemical, lumber, food processing, paper, and transportation equipment manufacturing.

The diversified mineral resources are of vital importance to the economy of both the local area and the entire Nation. In addition to the large oil reserves are coal, lead, zinc, bauxite, limestone, gypsum, and salt.

The average rainfall varies from 12 inches per year in the western great plains of Texas, Oklahoma, and New Mexico to 55 inches per year in the southeast in Arkansas and Louisiana. 1/ The southwest and central plains region of the United States is well known for wide fluctuations in rainfall. Both floods and extended droughts are common. Three times during the past 70 years (1892-94, 1934-36, and 1952-56) droughts have been so severe that extensive crop damage and serious water shortages have resulted. 3/

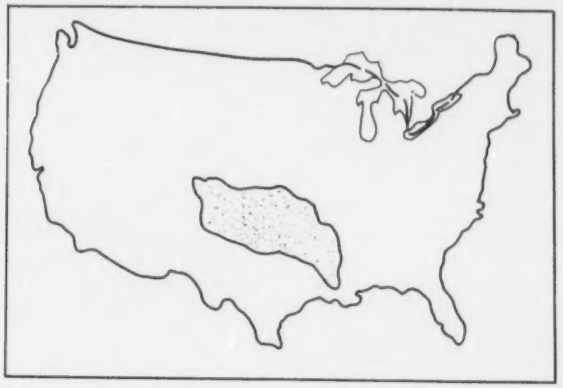


ARKANSAS — RED RIVER BASINS
WATER QUALITY CONSERVATION STUDY

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

REGION VII FEB 1968 DALLAS, TEXAS

ARKANSAS-RED RIVER



NEOSHO RIVER
VERDIGRIS RIVER
WICHITA
JOPLIN
TULSA
OKLAHOMA CITY
ARKANSAS RIVER
FT. SMITH
PETIT JEAN
LITTLE ROCK
OUACHITA RIVER
RED RIVER
LITTLE RIVER
WICHITA FALLS
LAKE TEXOMA
DALLAS
FT. WORTH
SHREVEPORT
ALEXANDRIA
N

ER BASINS

PLATE 1

Statistical studies indicate that the severity of the 1952-56 drought has a recurrence expectancy of once in 40 years in Texas and once in 140 years in Kansas and Oklahoma but may occur more often. 3/

The average annual flows of the Arkansas River at Little Rock, Arkansas, and of the Red River at Shreveport, Louisiana, for the period of record through Water Year 1955-56 are 29,200,000 acre-feet and 18,000,000 acre-feet respectively. Averages mean little, however, since flows are much less during drought years when the water is needed most. For the calendar year 1956, runoff of the Arkansas River at Little Rock, Arkansas, was 6,160,000 acre-feet while the runoff of the Red River at Shreveport, Louisiana, was 5,590,000 acre-feet. This was the lowest runoff of record in both rivers for one calendar year. 4/

Inorganic pollution in this area is caused by the discharge of oil field brine and the leaching of soluble minerals from geologic formations. The States in the project area, with the exception of New Mexico, are heavy producers of oil. The oil is mixed with varying percentages of salt brine as it is pumped from the ground. This salt water is separated from the oil in the vicinity of the oil wells and is disposed of either by injection to underground formations or by impounding on the surface. Serious deterioration of the quality of water resources occurs when oil field brine is improperly handled and is allowed to enter either fresh water aquifers or surface watercourses.

Plate III shows the areas of heavy and general oil production and the location of known mineral formations which contain gypsum (hydrous calcium sulfate). Several areas designated as salt plains are included on the plate. For the purpose of this report, salt plains are defined as areas underlain by mineral formations containing rock salt through which water percolates leaching out chlorides. On these plains the percolating water appears at the surface of the ground and often forms salt marshes (plains).

2. Purpose of the Project

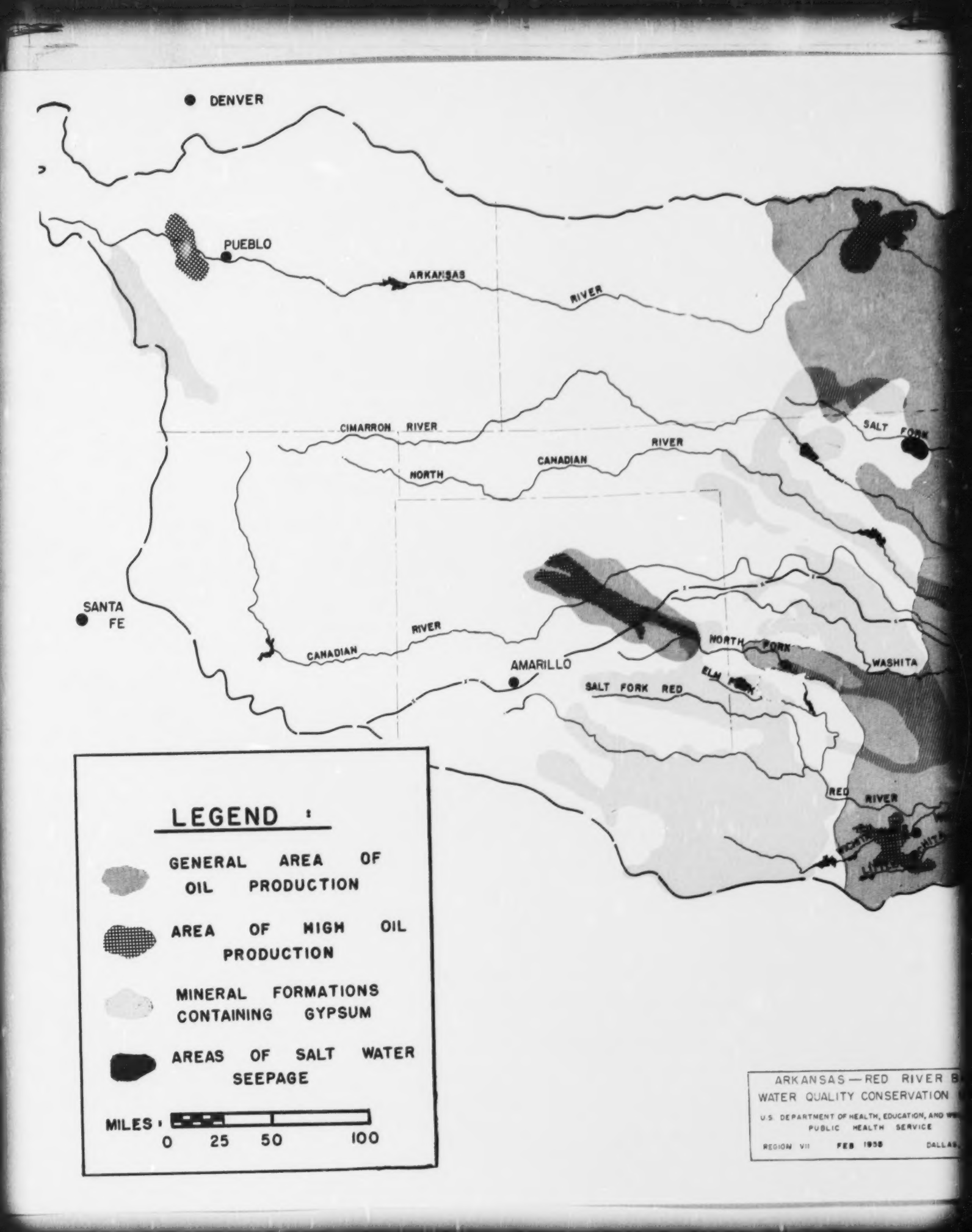
The Arkansas-Red River Basins Water Quality Conservation Project was initiated to determine where and how the quality of the waters of the Arkansas and Red River Basins can be improved. There is a general lack of factual information which might be used to determine the practicability of the control of mineral pollution. When such information is obtained, the basis for future planning for water pollution control and resource development will be much improved.

The Arkansas-Red River Basins Water Quality Conservation Project has three principal objectives:

(a) The determination of various factors which cause mineral degradation of the waters of the Arkansas and Red River Systems.

(b) The identification of waters of varying quality suitable for beneficial use, including quantity and location.

(c) The development of methods or measures for the improvement of the over-all water quality.


DENVER
PUEBLO
ARKANSAS
RIVER
CIMARRON RIVER
NORTH
CANADIAN
RIVER
SALT FORK
SANTA FE
CANADIAN
RIVER
AMARILLO
NORTH FORK
WASHITA
SALT FORK RED
ELM FORK
RED RIVER
LEGEND :
GENERAL AREA OF OIL PRODUCTION
AREA OF HIGH OIL PRODUCTION
MINERAL FORMATIONS CONTAINING GYPSUM
AREAS OF SALT WATER SEEPAGE
MILES :
0 25 50 100
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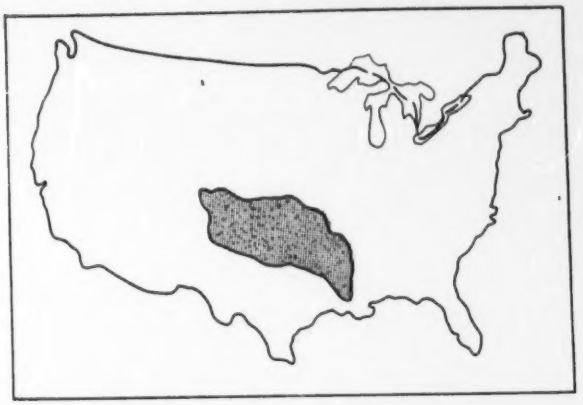
WATER QUALITY CONSERVATION
U.S. DEPARTMENT OF HEALTH, EDUCATION, AND
PUBLIC HEALTH SERVICE
REGION VII
FEB 1958
DALLAS



JOPLIN

SALT FORK

OKLAHOMA CITY

ARKANSAS RIVER

FT. SMITH

LITTLE ROCK

WASHITA RIVER

OUACHITA RIVER

RED RIVER

LITTLE RIVER

WICHITA FALLS

DALLAS

FT. WORTH

SHREVEPORT

ALEXANDRIA

N

—RED RIVER BASINS
Y CONSERVATION STUDY

EALTH, EDUCATION, AND WELFARE
EALTH SERVICE

1958 DALLAS, TEXAS

PLATE III

3. Scope of the Project.

(a) The project is organized in four specific phases in terms of time.

Phase 1. All known information, both published and unpublished, concerning water quality in the area will be assembled and studied in this period.

The completion of Phase 1 is scheduled for June 30, 1958.

Phase 2. Field studies will be made to fill the gaps in existing information. This will require the establishment of additional quality and discharge stations. Specific sources of pollution will be located.

The field investigations will include the determination of stream flow and water quality data; the inspection of areas of oil production for inadequate brine disposal and the precise location of salt springs, marshes, outcrops of mineralized formations, and other natural sources of pollution. The effect these pollutants have on the quality of water in the two basins will be determined to the extent practicable.

This portion of the project will also include a number of field investigations centered in areas where little or no data are now available, and where existing information indicates a problem.

A detailed field investigation of natural and other inorganic pollution in the Wichita and Little Wichita River Basins, both of which are tributary to the Red River, is under way. This investigation is being conducted jointly by the Texas State Department of Health and the Public Health Service. Each agency is providing personnel and necessary equipment.

The completion of Phase 2 is scheduled for June 30, 1960.

Phase 3. Basic data and all other information will be carefully evaluated during this period in an effort to develop practical pollution control proposals.

Methods under consideration for the control or abatement of inorganic pollution include: (1) Adoption, where indicated, of adequate methods of oil field brine disposal. (2) Diversion of salt springs or sealing off of localized mineral formations when found to be practicable. (3) Off-channel storage of very poor quality water for protection of existing watercourses. (4) Off-channel storage of high quality water for future municipal, industrial, or agricultural use. (5) The dilution of poor quality water with high quality water.

This phase will begin as soon as sufficient information has been obtained, assembled, and summarized. The statistical analysis will be in sufficient detail to insure an adequate background for practical recommendations for the elimination or reduction of sources of inorganic pollution and for the efficient utilization of present water resources for the maximum benefit of the area.

The completion of Phase 3 is scheduled for June 30, 1961.

Phase 4. The implementation of the plans and recommendations contained in the project will be carried out during this period. The construction of water resource development facilities is not within the province of the PHS. Implementation of the recommendations contained in the project will probably be accomplished by interested private agencies, local public agencies, and State and Federal construction agencies.

The implementation of Phase 4 will cover an indeterminate period.

(b) Contracts.

The need for special research on certain problems is apparent as the project progresses. Since this research usually can be performed most economically by other groups which specialize in it, contracts with outside groups are being integrated into the over-all project.

A contract has been made with North Texas State College, Denton, Texas, whereby the College will obtain data on the waters of the Red River arm and lower portions of Lake Texoma, in order to determine the effects of mineralization and temperature on the stratification of the lake. This information will be of value for the determination of water quality stored in the reservoir itself, and may be projected to the design and operation of other large reservoirs in the Arkansas and Red River Basins.

It is anticipated that other contracts will be negotiated as the need for specialized services arise.

(c) Cooperative Arrangements with other State and Federal Agencies.

In addition to supplying data, several agencies have actively joined the Public Health Service in making the study. The Texas State Department of Health is furnishing personnel and facilities to assist with field investigations in the State of Texas. The Kansas State Board of Health has indicated particular interest in oil field brine pollution and will supply personnel for field investigations in Kansas.

The Oklahoma and New Mexico State Departments of Health have indicated willingness to assist in connection with the field investigation phase of the project in their States. The Water Resources Board of Oklahoma will sponsor comprehensive water quality studies of the Washita River from Chickasha, Oklahoma, to Lake Texoma. This study will include information on the Washita arm of Lake Texoma. The lake data will be correlated with that obtained by North Texas State College for other parts of the lake, and will ultimately provide information on water quality variations within the reservoir. The Corps of Engineers is participating in the Lake Texoma studies.

(d) Organization of Project.

Administrative responsibility for the conduct of the project is centered in the Regional Office, Dallas, Texas, Public Health Service, U. S. Department of Health, Education, and Welfare.

A Technical Review Committee and a Special Consultant* assist the project staff. The Technical Review Committee recommends procedures and reviews the progress of the project. Their guidance and review of progress are considered important and vital.

4. Conduct of Project.

(a) Assembly and Tabulation of Data

During the period July 1, 1957 through February 1958, private agencies and local, State and Federal Governmental Agencies were canvassed for published and unpublished water quality data, discharge data, and other information on the subject. The Federal and State Agencies which furnished the majority of this information included the Geological Survey and Bureau of Reclamation of the U. S. Department of the Interior; the State Departments or Boards of Health and other State Agencies concerned with water pollution control, including the Texas Board of Water Engineers and the Oklahoma Water Resources Board.

In the data analysis, special consideration has been given to basic data collected from stations operated continuously for more than a one-year period with samples collected at least once each day. The degree of accuracy of the results of the statistical studies increases with longer periods of data collection.

Most stations are referred to throughout this report as continuous sampling stations providing continuous data. All other stations and data are referred to as non-continuous, regardless of whether samples were taken for analysis at intermittent, weekly, or monthly intervals, or on a one-time basis.

As most of the continuous data originated from stations operated by the U. S. Geological Survey and appeared in its publications tabulated on the basis of a water year, all data have been grouped in accordance with U. S. Geological Survey practice. The Water Year 1957-58 begins October 1, 1957 and ends September 30, 1958.

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* Technical Review Committee includes Burdge Irelan, District Chemist, Branch of Quality of Water, U. S. Geological Survey, Austin, Texas; Maurice LeBosquet, Jr., Assistant Chief, Water Supply and Water Pollution Control Program, Public Health Service, U. S. Department of Health, Education, and Welfare, Washington, D. C.; W. W. Towne, Chief, Water Pollution Control Unit, Robert A. Taft Sanitary Engineering Center, Public Health Service, U. S. Department of Health, Education, and Welfare, Cincinnati, Ohio. Dwight F. Metzler, Chief Engineer, Kansas State Board of Health, Topeka, Kansas acts as the Special Consultant. (Richard S. Green, Chief Basic Data and Economics Section, Water Supply and Water Pollution Control Program, Public Health Service, U. S. Department of Health, Education, and Welfare, Washington, D. C. replaced Mr. LeBosquet in June 1958.)

Water quality data from 87 continuous sampling stations and corresponding discharge information from 80 stations have been assembled for evaluation. Plate II shows the location of these stations on the Arkansas and Red River Systems. The numbers from 1 through 612 for the stations shown on Plate III and in Table IV are designations of the U. S. Geological Survey in Water Supply Paper No. 1311. Numbers 613 and above represent a designation given to the stations by the Public Health Service for this study, and are, therefore, not listed in the Water Supply Paper. The periods for which quality and quantity data are available are listed in Tables IV and V for each station.

Appendix II lists the continuous sampling stations in each basin together with a summary of the amount of the quality and discharge data available for the stations listed. While the quality data cover only the periods 1945 through 1956, the discharge data date to the early 1900's in some cases. A total of 290 station-years of water quality data has been assembled.

A comparison of water quality data collected in the early 1900's with recent data reveals that many streams and rivers have changed very little in water quality during the half century. Three streams that do show great variance are the Walnut River, the lower portion of the Little River of the Canadian, and the North Canadian River below Oklahoma City, Oklahoma. For each of these three streams the early records consistently showed water of low mineral content, low in chlorides, while the recent records indicate a marked increase in the chloride and total dissolved solids content of the stream waters.

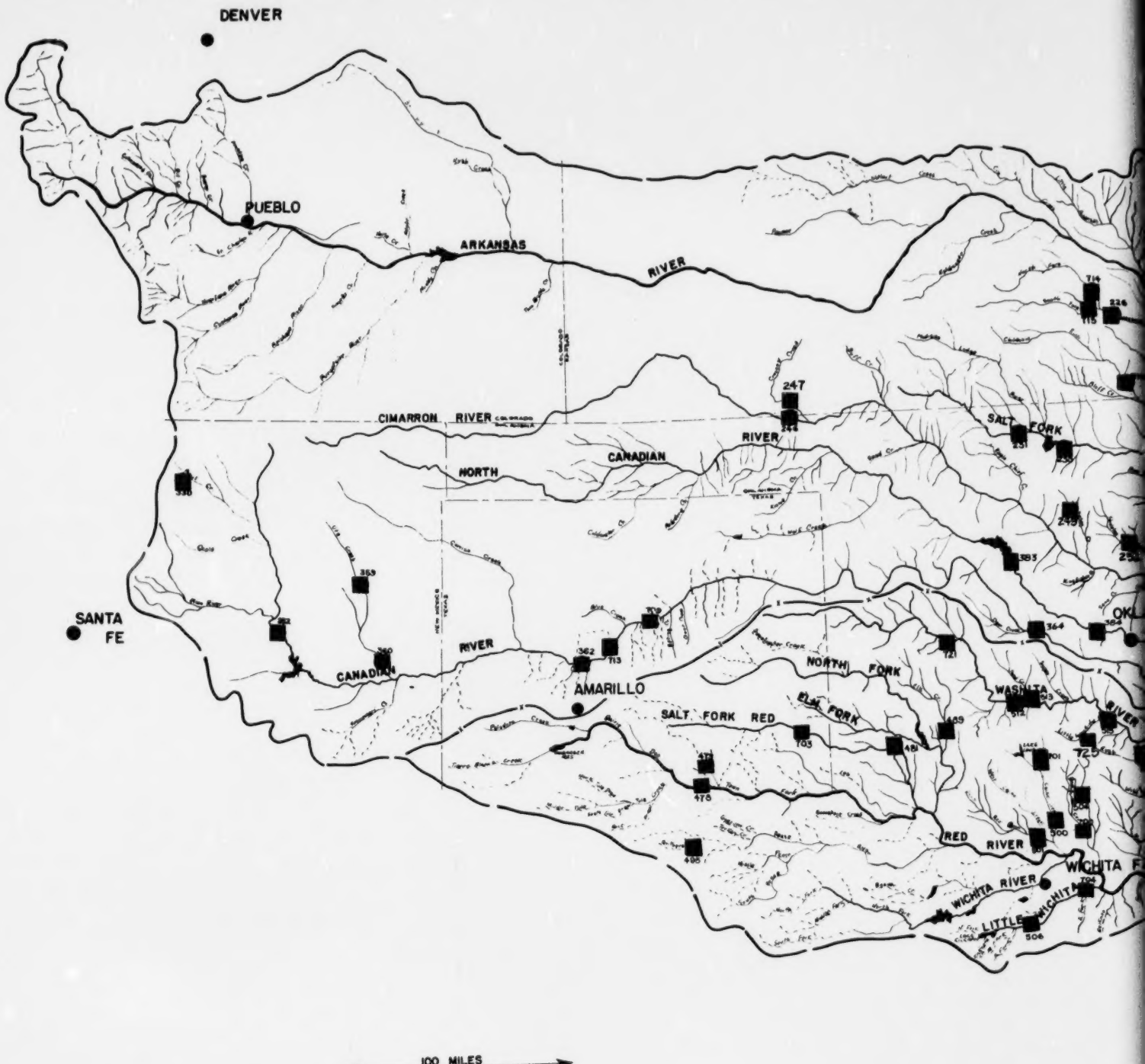
(b) Analysis of Data

Evaluation of the mineral content of stream waters has been started using three parameters -- chlorides, sulfates, and total dissolved solids. For each parameter, stream loadings have been calculated in tons per day and average concentrations in parts per million weighted according to flow. The resulting individual and summary values are shown for the stations on the Red River at Gainesville, Texas, and the Arkansas River at Tulsa, Oklahoma, in Appendix III. Summary quality and quantity data for all continuous stations through Water Year 1956-57 will be published as a supplement to this report.

The summarized information has been analyzed by two methods. The first utilizes cumulative frequency distribution curves and the second the quantity and quality profiles.

Cumulative frequency distribution curves were developed for the continuous sampling stations at Tulsa, Oklahoma, and Gainesville, Texas, as shown on Plates IV and V. Figure 1 of these plates is a plot of concentration vs. accumulated runoff. Figure 2 is a plot of concentration vs. accumulated days of occurrence of runoff, a quality-duration curve. Figure 3 is a plot of the probability of occurrence of annual average discharge.

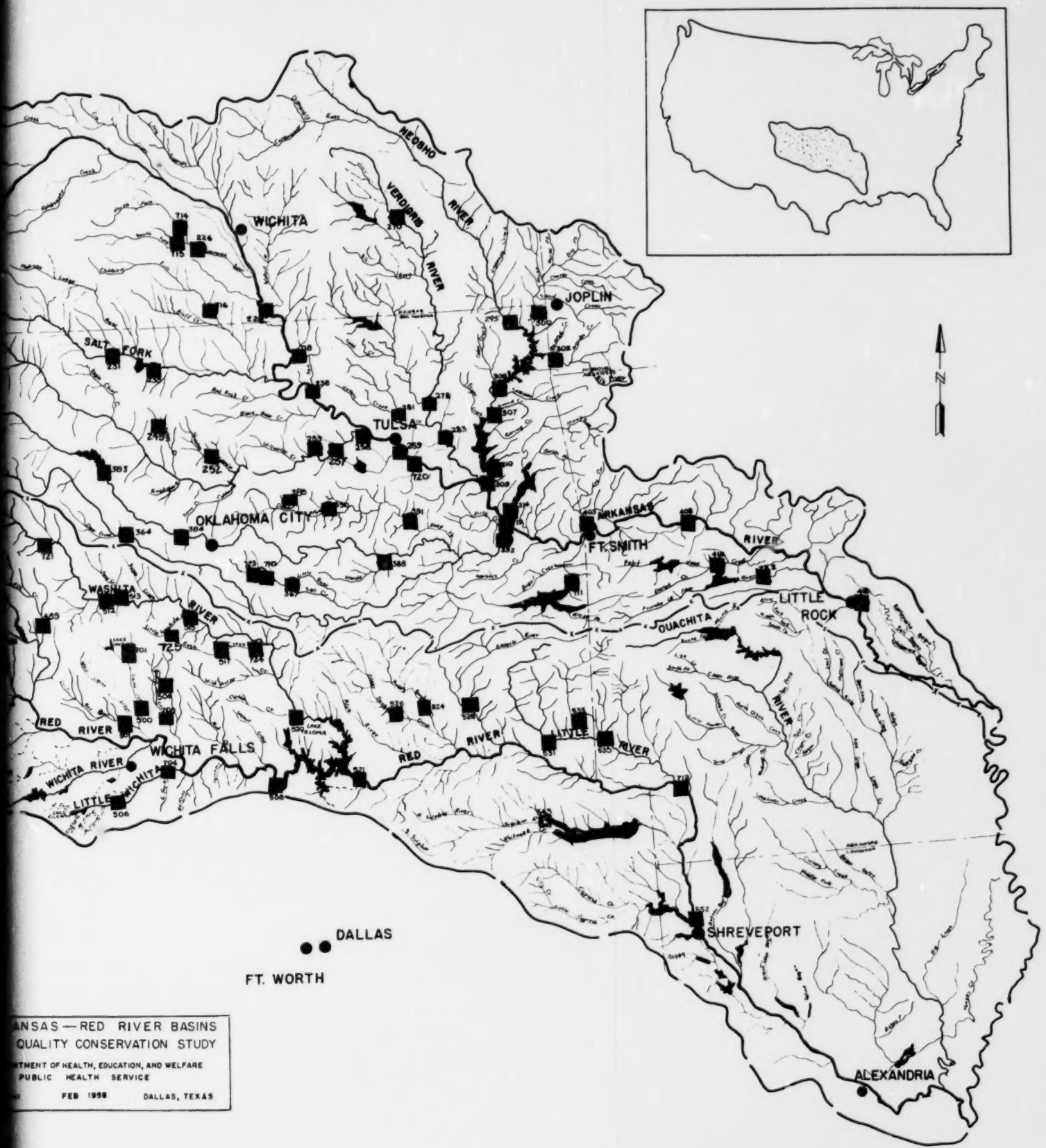
The curves in Figure 1 will permit determination of the yield of water per year of a quality having a mineral concentration equal to or less than a given value which occurred at this station during its period



ARKANSAS — RED RIVER BASINS
WATER QUALITY CONSERVATION STUDY
U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
REGION VII FEB 1958 DALLAS, TEXAS

LOCATION OF CONTINUOUS SAMPLING STATIONS
FROM WHICH DATA HAVE BEEN ASSEMBLED, SUMMARIZED AND
EVALUATED

■ STATIONS IN ARKANSAS AND RED RIVER BASINS



ANSAS—RED RIVER BASINS
QUALITY CONSERVATION STUDY
RTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
FEB 1958 DALLAS, TEXAS

PLATE II

ARKANSAS RIVER BASIN

STATION	NO.
Arkansas River at Arkansas City, Kansas	228
Arkansas River at Dardanelle, Arkansas	408
Arkansas River at Little Rock, Arkansas	418
Arkansas River at Ralston, Oklahoma	238
Arkansas River near Tulsa, Oklahoma	259
Arkansas River at Van Buren, Arkansas	403
Bell Cow Creek at Chandler, Oklahoma	389
Bird Creek near Sperry, Oklahoma	281
Canadian River near Amarillo, Texas	362
Canadian River at Bridgeport, Oklahoma	364
Canadian River near Sanchez, New Mexico	382
Canadian River at Tascosa, Texas	713
Canadian River at Whitefield, Oklahoma	382
Chickaskia River near Corbin, Kansas	716
Cimarron River at Munsford, Oklahoma	258
Cimarron River at Macame, Oklahoma	246
Cimarron River at Clifton, Oklahoma	257
Cimarron River at Perkins, Oklahoma	253
Cimarron River (at Canadian) at Ute Park, New Mexico	330
Crooked Creek near Nye, Kansas	247
Deep Fork River at Beggs, Oklahoma	390
Deep Fork River at Dewar, Oklahoma	391
Elk River near Tiff City Missouri	302
Illinois River at Tenkiller Res. near Gore, Oklahoma	314
Little River (below Hog Creek) near Norman, Oklahoma	710
Little River near Norman, Oklahoma	723
Little River at Sasakwa, Oklahoma	367
Neosho River near Commerce, Oklahoma	295
Neosho River at Ft Gibson Res. near Ft Gibson, Oklahoma	310
Neosho River at Langley, Oklahoma	305
Neosho River at Wagoner, Oklahoma	309
Ninnescah River at Peck, Oklahoma	226
North Canadian at Canton Res. near Canton, Oklahoma	383
North Canadian near El Reno, Oklahoma	364
North Canadian at Wetumka, Oklahoma	388
North Fork Ninnescah River near Cheney, Kansas	714
Petit Jean Creek at Danville, Arkansas	413
Poteau River at Wister Res. near Wister, Oklahoma	711
Salt Fork at Alva, Oklahoma	231
Salt Fork near Jet, Oklahoma	235
Skeleton Creek near Lovell, Oklahoma	252
South Fork Ninnescah near Murdock, Kansas	715
Spring River near Quapaw, Oklahoma	300
Turkey Creek near Drummond, Oklahoma	249
Ute Creek near Bueyeros, New Mexico	359
Ute Creek near Logan, New Mexico	360
Verdigris River near Claremore, Oklahoma	278
Verdigris River at Inola, Oklahoma	283
Verdigris River at Lenapah, Oklahoma	270
Arkansas River at Binky, Oklahoma	119
Arkansas River at Kaw City, Oklahoma	118
Arkansas River at Webber Falls, Oklahoma	720
Canadian River near Borger, Texas	109
Fourche La Fave River near Alpin, Ark.	722
Neosho River near Choteau, Oklahoma	307

WTR YR — 1945 | 1946 | 1947 | 1948 | 1949

O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F

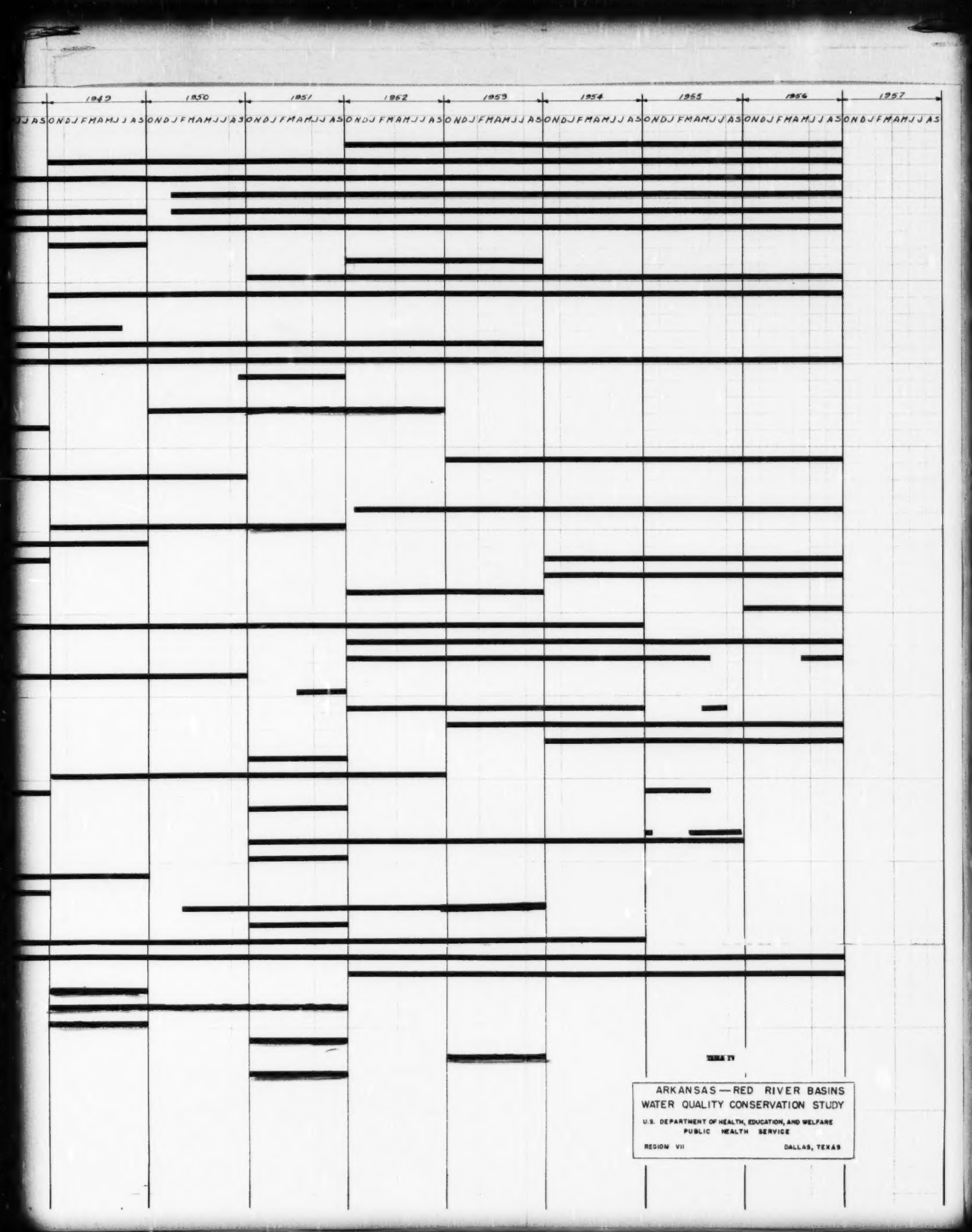
LEGEND

STATIONS WITH CORRESPONDING DISCHARGE

STATIONS WITHOUT CORRESPONDING DISCHARGE

ARKANSAS RIVER BASIN

CHART SHOWING CONTINUOUS SAMPLING STATIONS FOR WATER YEARS 1945 THROUGH 1956 (OCT. 1, 1945 THROUGH SEPT. 30, 1956) AND YEARS DATA WERE AVAILABLE AT EACH STATION


1949
1950
1951
1952
1953
1954
1955
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J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S
TEXAS
ARKANSAS — RED RIVER BASINS
WATER QUALITY CONSERVATION STUDY
U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
REGION VII
DALLAS, TEXAS

RED RIVER BASIN

STATION	NO.
Beaver Creek near Waurika, Oklahoma	700
Cache Creek at Waltens, Oklahoma	500
Clear Boggy Creek near Caney, Oklahoma	526
Deep Red Run near Randlett, Oklahoma	501
East Cache Creek near Elgin, Oklahoma	701
Elk Creek near Hobart, Oklahoma	489
Kiamichi River near Belzoni, Oklahoma	528
Little Beaver Creek near Duncan, Oklahoma	504
Little River near Horatio, Arkansas	535
Little River near Idabel, Oklahoma	531
Little Washita River near Ninnekah, Oklahoma	725
Little Wichita River near Archer City, Texas	506
Little Wichita River near Henrietta, Texas	704
Mountain Fork near Eagletown, Oklahoma	533
Muddy Boggy near Farris, Oklahoma	528
Mulberry Creek at Bryce, Texas	479
Prairie Dog Town Fork of Red River near Bryce, Texas	478
Pond Creek near Ft. Cobb, Oklahoma	513
Quitaque Creek near Quitaque, Texas	495
Red River at Fulton, Arkansas	712
Red River at Gainesville, Texas	508
Red River at Denison Dam near Denison, Texas	522
Red River near Shreveport, Louisiana	552
Rush Creek near Haggville, Oklahoma	724
Rush Creek near Purdy, Oklahoma	517
Salt Fork Red River near Wellington, Texas	703
Salt Fork Red River near Mangum, Oklahoma	481
Sulphur River at Dandon, Texas	543
Washita River at Cannage, Oklahoma	512
Washita River near Durwood, Oklahoma	520
Washita River near Tabler, Oklahoma	515
Washita River near Foss dam, site 1 (no corresponding discharge) Oklahoma	721

WTR. YR.

1945 1946 1947 1948 1949

O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J

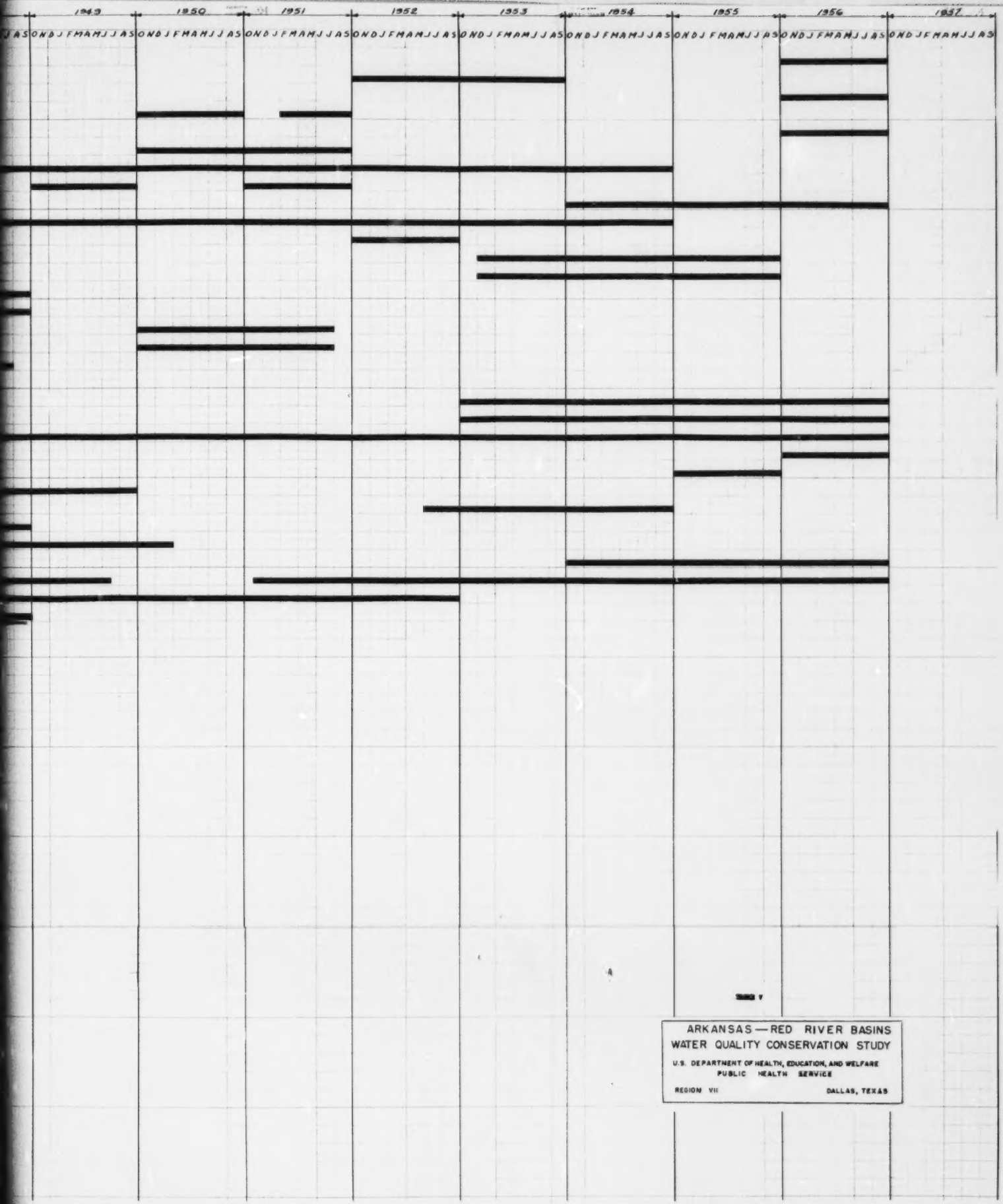
RED RIVER BASIN

CHART SHOWING CONTINUOUS SAMPLING STATIONS FOR WATER YEARS 1945 THROUGH 1956 (OCT. 1, 1945 THROUGH SEPT. 30, 1956) AND YEARS DATA WERE AVAILABLE AT EACH STATION

LEGEND

STATIONS WITH CORRESPONDING DISCHARGE

STATIONS WITHOUT CORRESPONDING DISCHARGE



ARKANSAS — RED RIVER BASINS
WATER QUALITY CONSERVATION STUDY

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

REGION VII DALLAS, TEXAS

of record. Figure 2 shows the number of days per year that flow occurs at a mineral concentration equal to or less than a given value. Figure 3 permits a visual examination and evaluation of the data; i.e. whether it represents a period of drier than normal, normal, or wetter than normal. The cumulative frequency distribution curves will also serve as bench marks, against which the effects of suggested control procedures can be measured.

Figure 1 of Plate IV indicates that during the periods of water quality record at station 259, Tulsa, Oklahoma, a yearly average of approximately 250,000 acre-feet of runoff occurred containing not more than 500 ppm of total dissolved solids, 200 ppm of chlorides, and 100 ppm sulfates. Figure 2 of Plate IV indicates that the runoff having this quality occurred in only an average of two days per year. Figure 3 of Plate IV indicates that the period of water quality record was taken during a period when the annual runoff was slightly in excess of normal. The period, however, does include two critically dry water years, 1954-55 and 1955-56.

Figure 1 of Plate V indicates that a yearly average of approximately 200,000 acre-feet of runoff occurred at station 508, Gainesville, Texas, during the period of quality record containing not more than 500 ppm of total dissolved solids. Figure 2, Plate V indicates these flows occurred on an average of 20 days per year. Figure 3, Plate V indicates that the period of record represents a drier than normal period including 1954-55 and 1955-56 water years.

Considerable quantities of relatively good water flow past these important stations each year. The duration of these flows is extremely short so that its capture is very difficult.

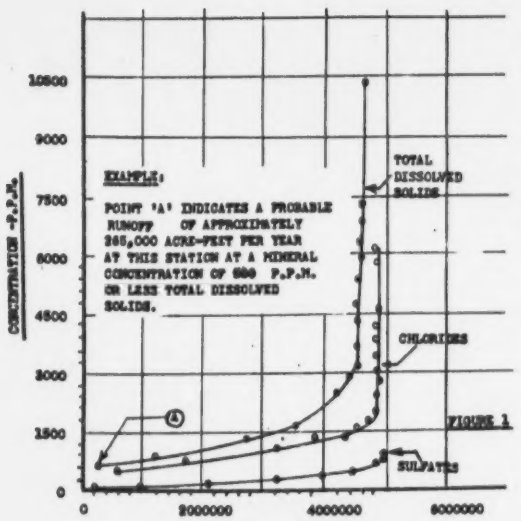
Further refinement of analytical procedures used in determining the yield and duration of flow will be developed for future reports.

A profile of qualitative and quantitative data has been superimposed on a schematic diagram of the two river systems for visual comparisons of quality at several gaging stations. The profiles show the summary of data collected during Water Year 1955-56 consisting of (1) weighted average mineral concentration in parts per million, (2) discharge readings in cubic feet per second, and (3) stream loadings in tons per day at each station. Plates VI and VII depict this information for the Arkansas and Red Rivers respectively. Data collected during Water Year 1955-56 were utilized because it is the year with the largest number of continuously operated stations, and it is indicative of critically low flow conditions. Data from 29 stations were available for inclusion in the profiles during this period. The three vertical segments of the bar graph from left to right represent (1) weighted average concentration in ppm of chlorides, sulfates, other dissolved solids, (2) average discharge in cfs, and (3) stream loadings or quantities of salt in tons per day of the same mineral constituents. The sum of the three figures representing chlorides, sulfates, and other dissolved solids equals the concentration and tons per day of total dissolved solids.

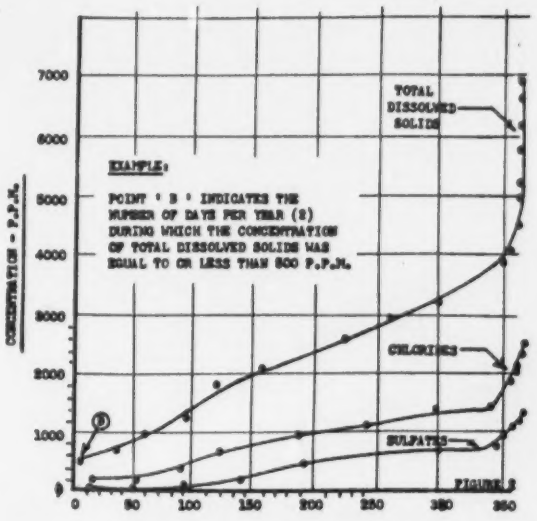
The total loadings in tons of chlorides, sulfates, and total dissolved solids should increase from the headwaters to the mouth of stream, even though the over-all quality or concentration of minerals in ppm may fluctuate over a wide range.

CUMULATIVE FREQUENCY DISTRIBUTION CURVES

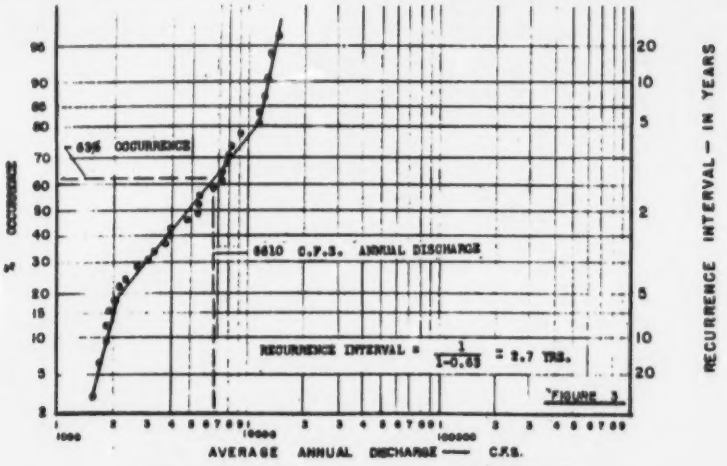
STATION: ARKANSAS RIVER NEAR TULSA, OKLAHOMA
STATION NO. 259
PERIOD OF RECORD: OCTOBER 1947 — SEPTEMBER 1956 (10 YEARS)


CONCENTRATION - P.P.M.
EXAMPLE:
POINT 'A' INDICATES A PROBABLE RUNOFF OF APPROXIMATELY 260,000 ACRE-FEET PER YEAR AT THIS STATION AT A MINERAL CONCENTRATION OF 800 P.P.M. OR LESS TOTAL DISSOLVED SOLIDS.
TOTAL DISSOLVED SOLIDS
CHLORIDES
SULPATES
A
FIGURE 1
RUNOFF IN ACRE FEET PER YEAR AT A MINERAL CONCENTRATION EQUAL TO OR LESS THAN THE VALUE SHOWN ON THE VERTICAL AXIS

RUNOFF vs. CONCENTRATION


CONCENTRATION - P.P.M.
EXAMPLE:
POINT 'B' INDICATES THE NUMBER OF DAYS PER YEAR (2) DURING WHICH THE CONCENTRATION OF TOTAL DISSOLVED SOLIDS WAS EQUAL TO OR LESS THAN 800 P.P.M.
TOTAL DISSOLVED SOLIDS
CHLORIDES
SULPATES
B
FIGURE 2
DAYS OF FLOW PER YEAR AT A MINERAL CONCENTRATION EQUAL TO OR LESS THAN THE VALUE SHOWN ON THE VERTICAL AXIS

DAYS OF FLOW vs. CONCENTRATION



PROBABILITY OF OCCURRENCE OF AVERAGE ANNUAL DISCHARGE

DATA DESCRIBED	PERIOD OF RECORD	AVERAGE ANNUAL DISCHARGE— C.F.S.
QUALITY DATA	OCT. 1947— SEPT. 1956	6610
DISCHARGE DATA	OCT. 1939— SEPT. 1956	6040

[1]RECURRENCE INTERVAL: 2.7 YRS.

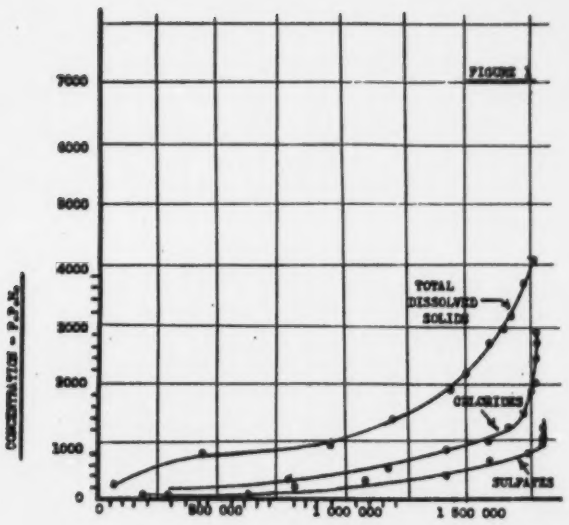
1. RECURRENCE INTERVAL FOR AVERAGE ANNUAL DISCHARGE DURING THE PERIOD OF QUALITY DATA.

ARKANSAS — RED RIVER BASINS
WATER QUALITY CONSERVATION STUDY
U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
REGION VII FEB. 1960 DALLAS, TEXAS

PLATE IV

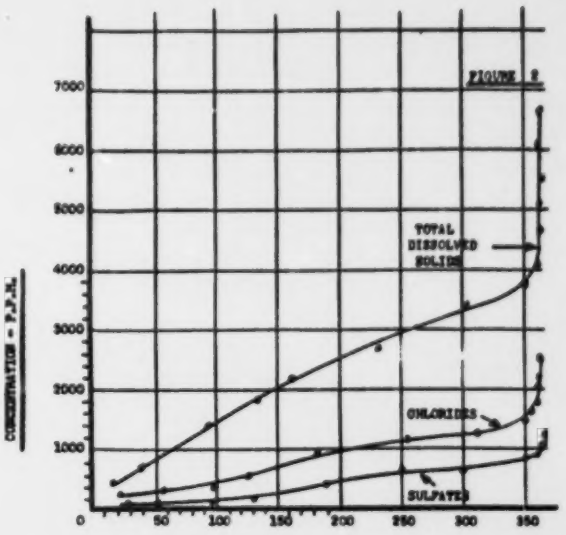
CUMULATIVE FREQUENCY DISTRIBUTION CURVES

STATION: RED RIVER NEAR GAINESVILLE, TEXAS
STATION NO.: 508
PERIOD OF RECORD: MAY 1944 THROUGH APRIL 1948 – OCTOBER 1952 THROUGH SEPTEMBER 1956 (8YRS.)



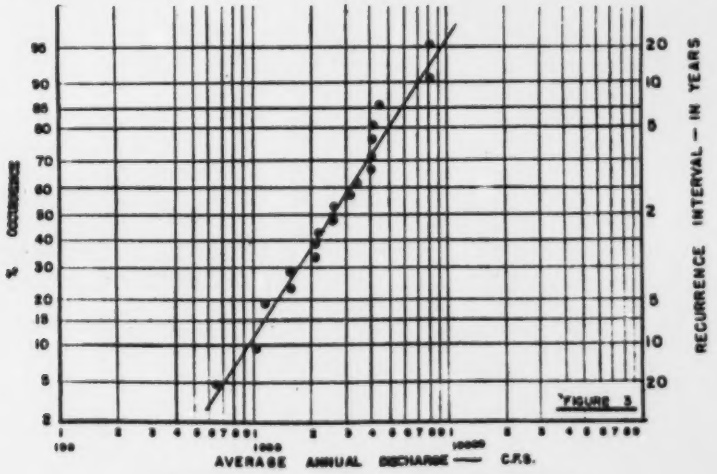
RUNOFF IN ACRE FEET PER YEAR AT A MINERAL CONCENTRATION EQUAL TO OR LESS THAN THE VALUE SHOWN ON THE VERTICAL AXIS

RUNOFF vs. CONCENTRATION



DAYS OF FLOW PER YEAR AT A MINERAL CONCENTRATION EQUAL TO OR LESS THAN THE VALUE SHOWN ON THE VERTICAL AXIS

DAYS OF FLOW vs. CONCENTRATION



PROBABILITY OF OCCURRENCE OF AVERAGE ANNUAL DISCHARGE

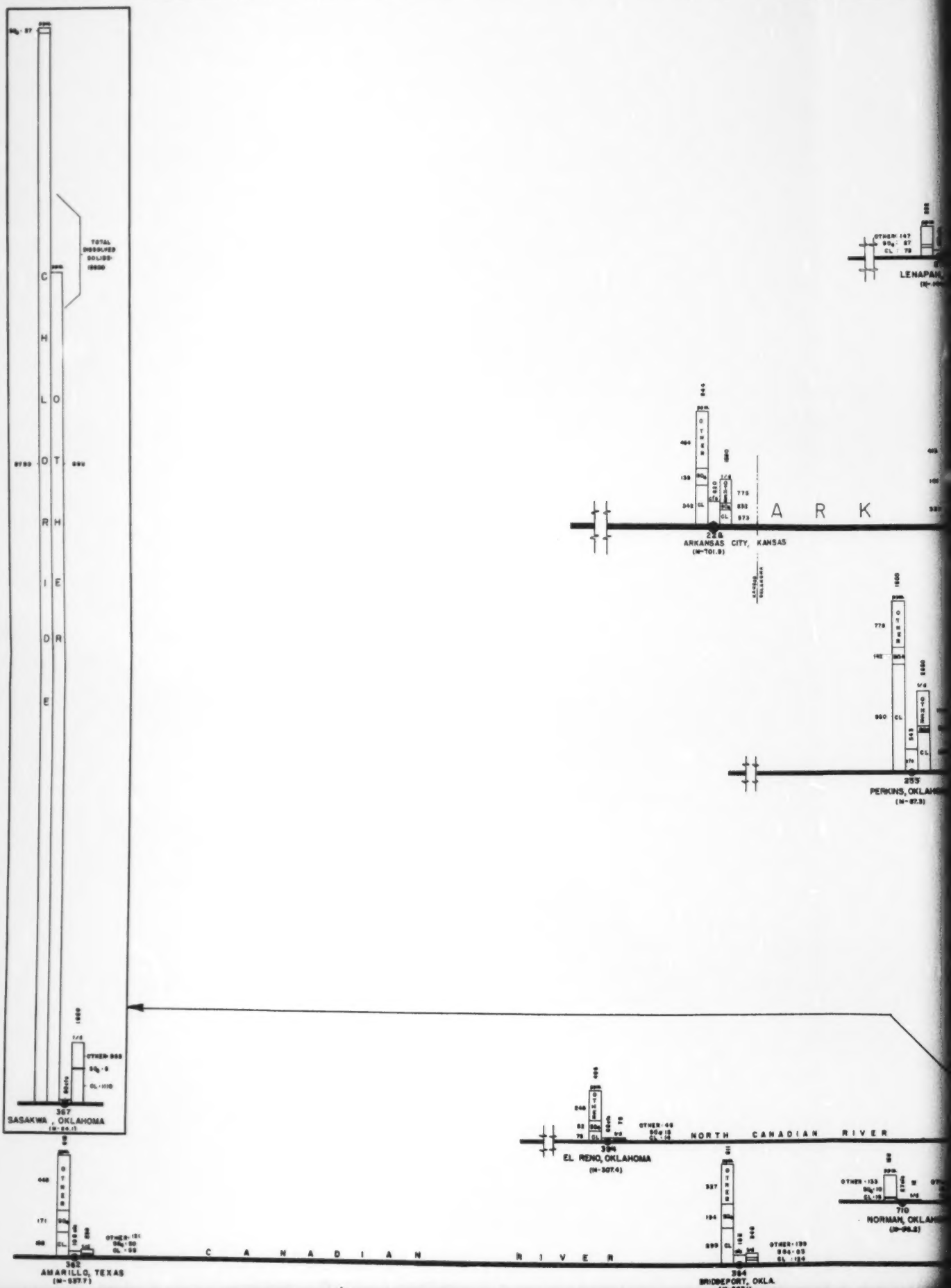
DATA DESCRIBED	PERIOD OF RECORD	AVERAGE ANNUAL DISCHARGE — C.F.S.
QUALITY DATA	MAY 1944 – APRIL 1948 OCT. 1952 – SEPT. 1956	2370
DISCHARGE DATA	OCT. 1937 – SEPT. 1956	3130

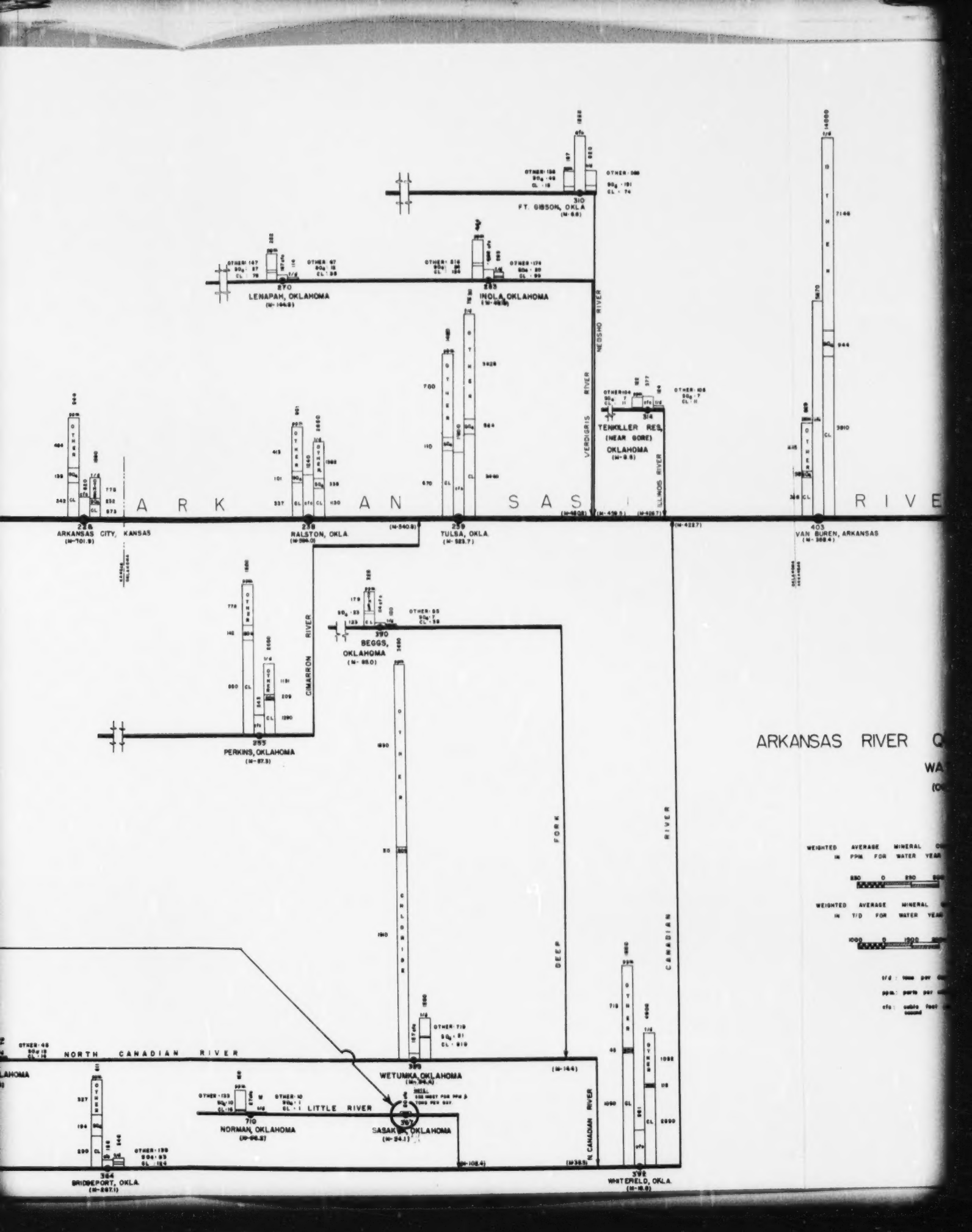
RECURRENCE INTERVAL: 2.2 YRS.

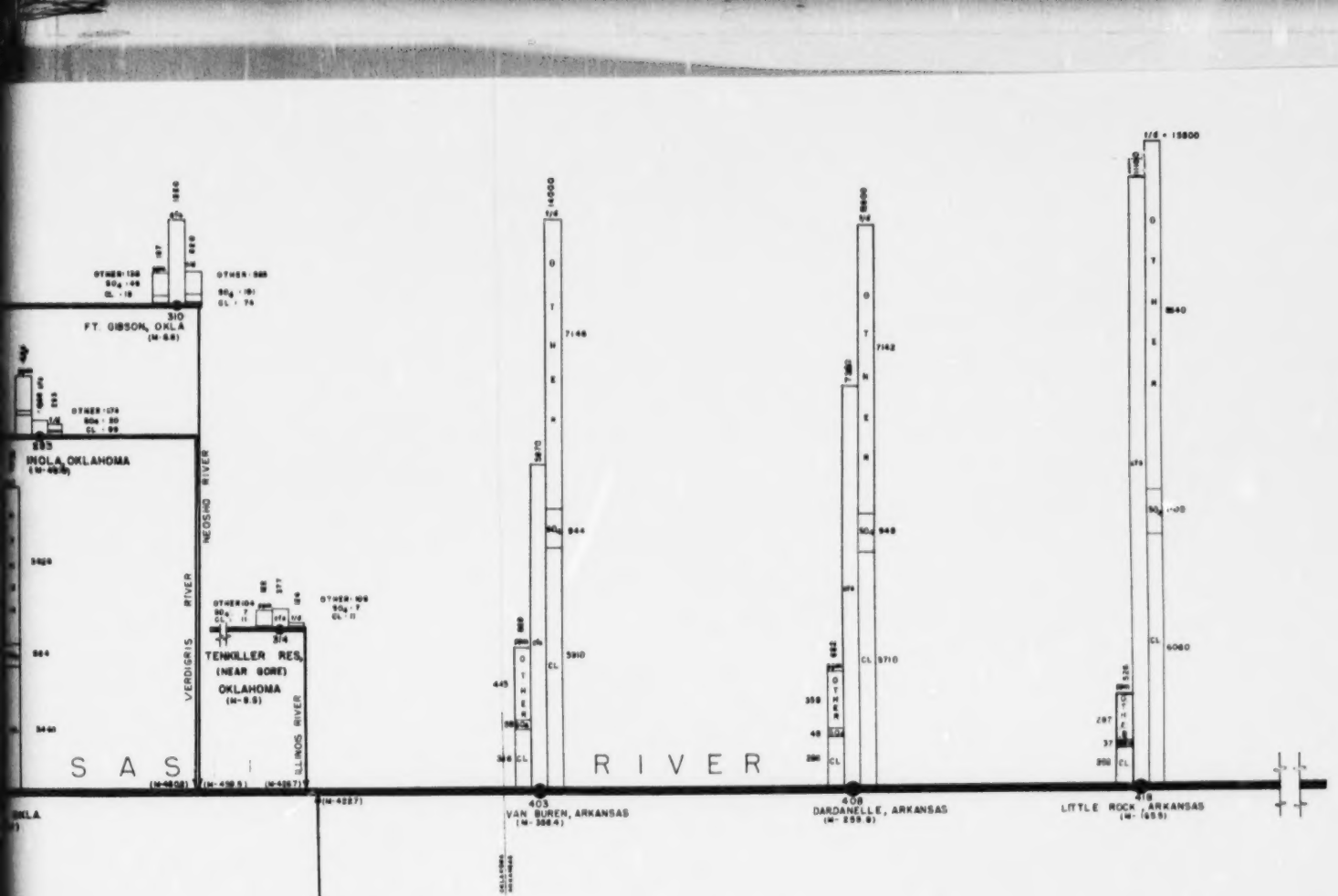
1. RECURRENCE INTERVAL FOR AVERAGE ANNUAL DISCHARGE DURING THE PERIOD OF QUALITY DATA.

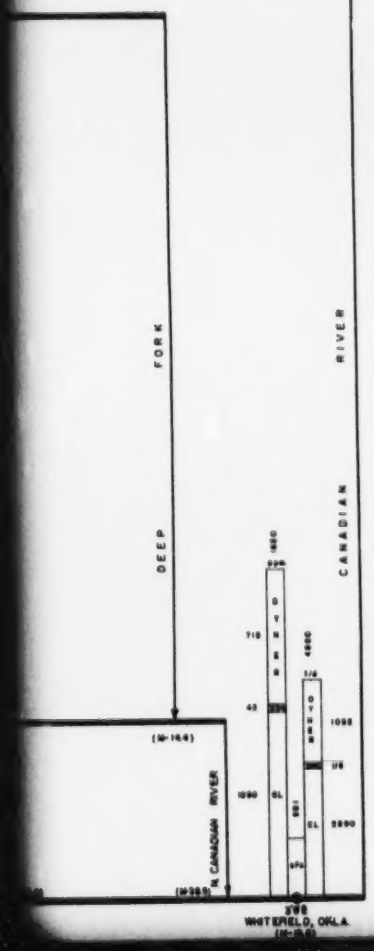
ARKANSAS — RED RIVER BASINS
WATER QUALITY CONSERVATION STUDY
U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
REGION VII FEB. 1958 DALLAS, TEXAS

PLATE V


CHLORIDE
TOTAL DISSOLVED SOLIDS-19000
OTHER-885
SO4-5
CL-1110
367
SASAKWA, OKLAHOMA
OTHER-147
SO4-87
CL-79
LENAPAH
ARK
OTHER
CL
284
ARKANSAS CITY, KANSAS
OTHER
CL
253
PERKINS, OKLAHO
NORTH CANADIAN RIVER
OTHER-49
SO4-15
CL-14
384
EL RENO, OKLAHOMA
OTHER-133
SO4-10
CL-15
710
NORMAN, OKLAH
OTHER-131
SO4-50
CL-55
362
AMARILLO, TEXAS
CANADIAN RIVER
OTHER-139
SO4-53
CL-126
384
BRIDGEPORT, OKLA.


ARKANSAS RIVER
ARKANSAS CITY, KANSAS
(M-701.9)
RALSTON, OKLA.
(M-594.0)
TULSA, OKLA.
(M-523.7)
VAN BUREN, ARKANSAS
(M-368.4)
FT. GIBSON, OKLA
(M-68)
LENAPAH, OKLAHOMA
(M-144.8)
INOLA, OKLAHOMA
(M-98.8)
TENKILLER RES.
(NEAR GORE)
OKLAHOMA
(M-9.8)
VERDIGRIS RIVER
NEOSHO RIVER
ILLINOIS RIVER
BEGGS,
OKLAHOMA
(M-85.0)
PERKINS, OKLAHOMA
(M-97.3)
CIMARRON RIVER
DEEP FORK
CANADIAN RIVER
NORTH CANADIAN RIVER
WETUMKA OKLAHOMA
(M-34.4)
NORMAN, OKLAHOMA
(M-96.2)
SASAKWA, OKLAHOMA
(M-24.1)
LITTLE RIVER
N. CANADIAN RIVER
BRIDGEPORT, OKLA.
(M-267.1)
WHITEFIELD, OKLA.
(M-15.8)
(M-540.8)
(M-4227)
(M-144)
(M-108.4)
(M385)
ARKANSAS RIVER Q
WA
(O
WEIGHTED AVERAGE MINERAL
IN PPM FOR WATER YEAR
WEIGHTED AVERAGE MINERAL
IN T/D FOR WATER YEAR
T/D : tons per
ppm: parts per
cfs: cubic feet
second





ARKANSAS RIVER QUALITY AND DISCHARGE PROFILE

WATER YEAR 1956

(OCTOBER '55 - SEPTEMBER '56)

SCALE

WEIGHTED AVERAGE MINERAL CONCENTRATION IN PPM FOR WATER YEAR 1956

250 0 250 500

AVERAGE DISCHARGE IN CFS FOR WATER YEAR 1956

750 0 750 1500

WEIGHTED AVERAGE MINERAL QUANITY IN IN T/D FOR WATER YEAR 1956

1000 0 1000 2000

RIVER MILEAGE IN MILES

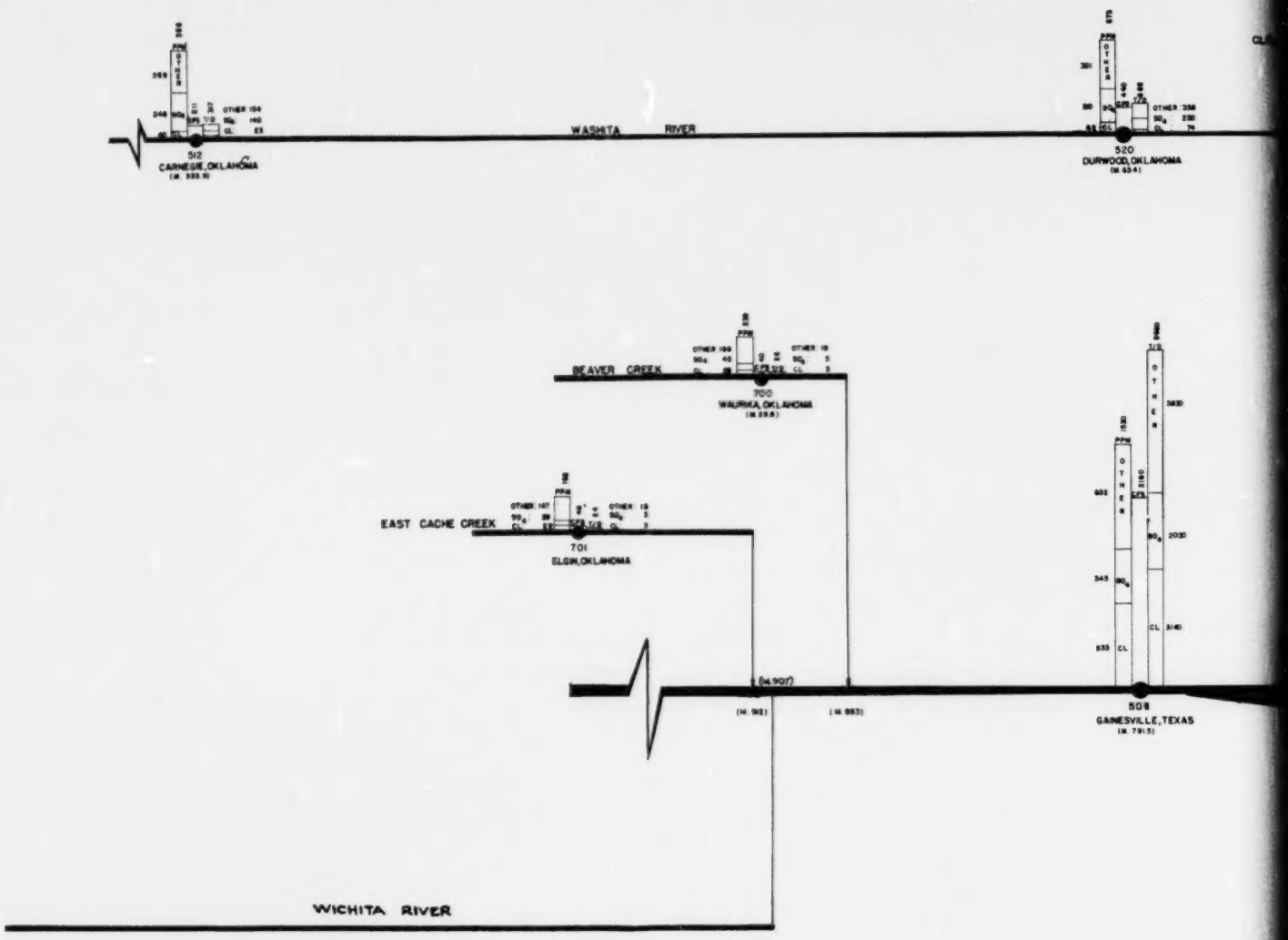
12.5 0 12.5 25

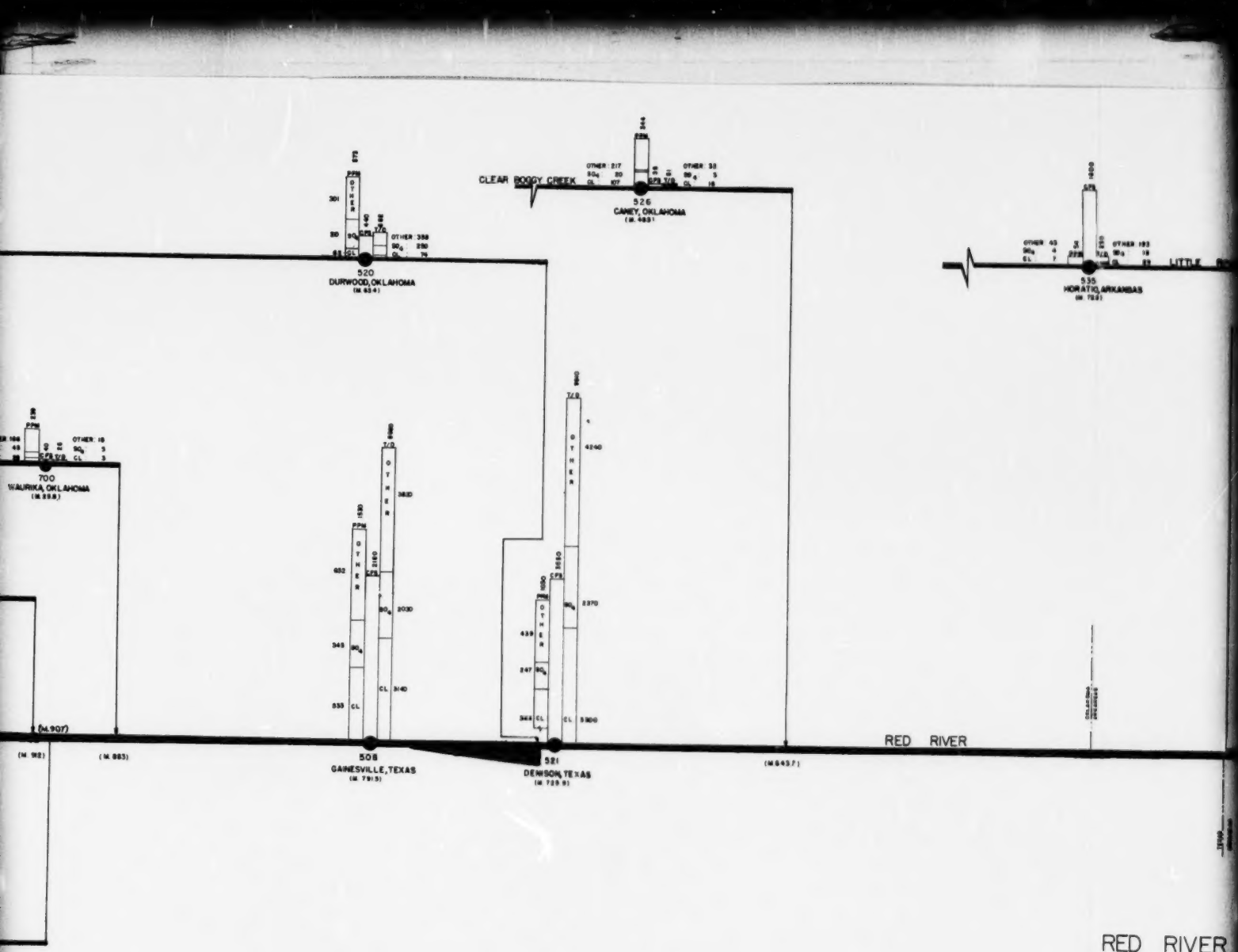
ABBREVIATIONS

T/d : tons per day
ppm : parts per million
cfs : cubic feet per second
OTHER : other dissolved solids
SO_4 : sulfates
CL : chlorides
0 : location of stations
259 station number
(M-383.7): river mile of station measured from mouth of river or tributary

ARKANSAS — RED RIVER BASINS
WATER QUALITY CONSERVATION STUDY
U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
REGION VII FEB 1959 DALLAS, TEXAS

PLATE VI


WASHITA RIVER
512
CARNEGIE, OKLAHOMA
520
DURWOOD, OKLAHOMA
BEAVER CREEK
700
WAURIKA, OKLAHOMA
EAST CACHE CREEK
701
ELGIN, OKLAHOMA
(M. 902)
(M. 883)
508
GAINESVILLE, TEXAS
WICHITA RIVER



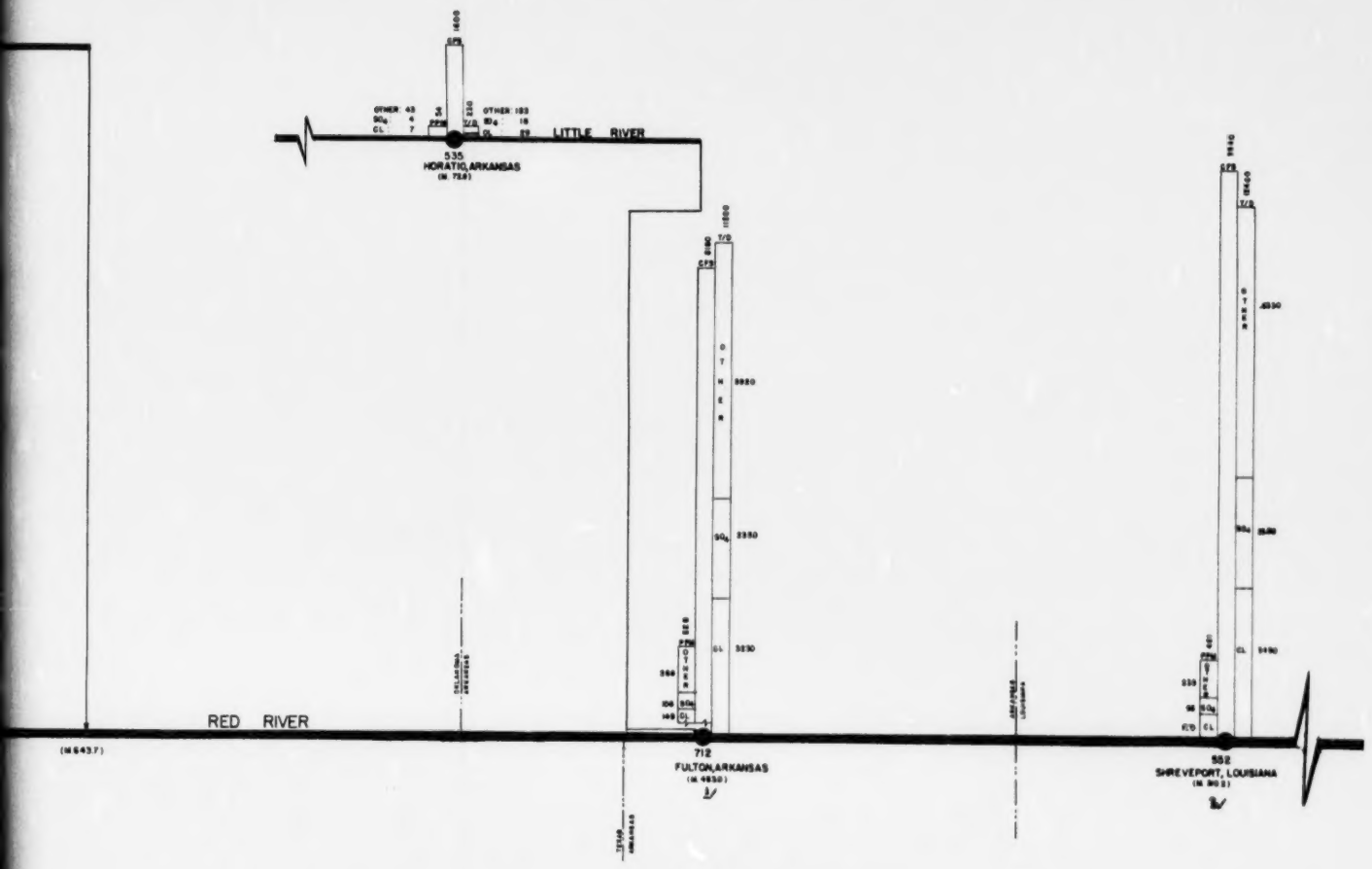
RED RIVER

WEIGHTED AVERAGE
IN PPM FOR
250 0

WEIGHTED AVERAGE
IN T/D FOR
1000 0

1/

2/



RED RIVER QUALITY AND DISCHARGE PROFILE

WATER YEAR 1956

(OCTOBER '55 - SEPTEMBER '56)

SCALE

WEIGHTED AVERAGE MINERAL CONCENTRATION IN PPM FOR WATER YEAR 1956

250 0 250 500

AVERAGE DISCHARGE IN CFS FOR WATER YEAR 1956

750 0 750 1500

WEIGHTED AVERAGE MINERAL QUANTITY IN T/D FOR WATER YEAR 1956

1000 0 1000 2000

RIVER MILEAGE IN MILES

12.5 0 12.5 25

ABBREVIATIONS

T/D : tons per day
ppm : parts per million
cfs : cubic feet per second
OTHER : other dissolved solids
SO4 : sulfates
CL : chlorides
o : location of station
508: station number
(M-791.3) : river mile of station measured from mouth of river or tributary

ARKANSAS — RED RIVER BASINS
WATER QUALITY CONSERVATION STUDY
U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
REGION VII FEB 1959 DALLAS, TEXAS

1/ QUALITY DATA NOT AVAILABLE FOR MARCH 30, 1956

2/ QUALITY DATA FOR FIRST 6 DAYS OF WATER YEAR 1956 NOT AVAILABLE

PLATE VII

The profiles may be used in several different ways, namely:

1. To compare the quality of water of the main stem and its tributaries at different locations and to determine the zones of deterioration.

2. To observe water discharge or flow patterns in the basins.

3. To estimate the mineral loadings and locate streams or areas which are heavy contributors to the quality deterioration of the main stem or its major tributaries.

4. To designate areas where, either because of evidence of major pollution or complete lack of evidence, detailed field investigations will be necessary.

Tables I, II and III have been prepared to show the proportion of total flow and the quantity of mineral matter being contributed by the principal tributaries and the main stream above three specific locations during Water Year 1955-56. These data indicate, for example, that the Little River of the Canadian contributed 5.1 percent of the flow in the Canadian River at Whitefield, Oklahoma, and only 0.83 percent of the flow in the Arkansas River at Van Buren, Arkansas, yet the quantity of mineral matter as measured by total dissolved solids is 40 percent of the load carried by the Canadian River at Whitefield and 14 percent of that carried by the Arkansas River at Van Buren. 5/

Data in Table II indicates that streams tributary to the Arkansas River other than the Cimarron between Ralston and Tulsa, Oklahoma, contribute a very small (3%) proportion of the flow; however, the mineral content is 27 percent of that carried by the Arkansas River at Tulsa. More information must be collected to evaluate the sources of this pollution.

Similar comparisons for specific locations on the Red River have not been made, primarily because of the lack of sufficient quality data above Gainesville, Texas.

5. General Observations.

a. Additional discharge and quality data, particularly in the Upper Red and Upper Cimarron, North Canadian, and Canadian River Watersheds, must be obtained before conclusions can be drawn about the sources and amounts of mineralization contributed by each river and its tributaries.

b. Summary data on some streams indicate substantial increases in total dissolved solids and chloride loads as rivers flow through oil fields without a corresponding increase in sulfates, indicating oil field pollution.

c. Summary data indicate that sizeable quantities of water with a concentration equal to or less than 250 parts per million chloride (Cl^-) are available at Tulsa and Gainesville even during drought periods; however, the good quality water occurs during short periods of time making its capture or diversion difficult.

REFERENCE LOCATION

Arkansas River at Van Buren, Arkansas - Water Year 1955-56

Table I

Station Number	Station location	Discharge CFS	Discharge %	Tot. Diss. Solids Tons/Day	Tot. Diss. Solids %
314	Illinois River at Tenkiller Res. near Gore, Okla.	377	6.3	124	0.9
310	Neosho River near Ft. Gibson Reservoir, Okla.	1550	26.0	820	5.9
83	Verdigris River at Inola, Oklahoma	298	5.0	293	2.1
392	Canadian River at Whitefield, Oklahoma	981	16.4	4900	35.0
259	Arkansas River at Ralston, Oklahoma	1240	20.8	2850	20.3
253	Cimmaron River at Perkins, Oklahoma	543	9.1	2650	18.9
	Estimated amount other sources including main stream Ark. River between Van Buren & Ralston	981	16.4	2363	16.9
403	Arkansas River at Van Buren, Arkansas	5970	100.0	14,000	100.0

REFERENCE LOCATION

Arkansas River at Tulsa, Oklahoma - Water Year 1955-56

Table II

Station Number	Station Location	Discharge CFS	Discharge %	Tot. Diss. Solids Tons/Day	Tot. Diss. Solids %
238	Arkansas River at Ralston, Oklahoma	1240	67.4	2850	37.8
253	Cimarron River at Perkins, Oklahoma	543	29.5	2650	35.1
	Estimated amount other sources including main stem Arkansas River bet. Tulsa & Ralston & Salt Fork	57	3.1	2040	27.1
259	Arkansas River at Tulsa, Oklahoma	1840	100.0	7540	100.0

REFERENCE LOCATION

Canadian River at Whitefield, Oklahoma - Water Year 1955-56

Table III

Station Number	Station Location	Discharge CFS	Discharge %	Tot. Diss. Solids Tons/Day	Tot. Diss. Solids %
386	North Canadian River at Wetumpka, Oklahoma	157	16.0	1550	31.6
367	Little River at Sasakwa, Oklahoma	50	5.1	1980	40.4
364	Canadian River at Bridgeport, Oklahoma	158	16.1	346	7.1
	Estimated amount other sources including main stem Canadian River bet. Bridgeport & Whitefield	616	62.8	1024	20.9
392	Canadian River at Whitefield	981	100.0	4900	100.0

d. Records of certain streams under study compiled early in the 20th century indicate high quality water. Inadequate early records prevent an over-all comparison of present stream quality with that of 50 years ago.

e. Extensive field investigations will be necessary to pinpoint sources of pollution.

References:

1/ Senate Document No. 13, 85th Congress, 1st Session.

2/ Drainage Area Data, AWR Basins, Corps of Engineers, U. S. Army, April, 1954.

3/ Weekly Weather and Crop Bulletin, Vol. XLIV, No. 1a, Weather Bureau, U. S. Department of Commerce.

4/ Water Supply Paper 1311 and other published and unpublished records of the Geological Survey, U. S. Department of the Interior.

5/ Refer to paper entitled "Water Quality - A Factor in Arkansas River Development" presented by Mr. T. B. Dover, District Chemist, Quality of Water Branch, U. S. Geological Survey, presented before the Tulsa, Oklahoma, Chamber of Commerce, July 22, 1957.

APPENDICES

APPENDIX I

CONTRIBUTORS TO ARKANSAS RED-RIVER BASINS WATER QUALITY CONSERVATION PROJECT

Arkansas Water Pollution Control Commission

Arkansas-White-Red Basins Inter-Agency Committee

City of Dallas, Texas

City of Oklahoma City, Oklahoma

City of Wichita, Kansas

City of Wichita Falls, Texas

Conservation Foundation - New York, New York

Kansas Gas and Electric Company - Wichita, Kansas

Kansas State Board of Agriculture

Division of Water Engineers - Topeka, Kansas

Kansas State Corporation Commission - Wichita, Kansas

Kansas Water Resources Board - Topeka, Kansas

Louisiana Department of Public Works - Baton Rouge, Louisiana

Midwestern University - Wichita Falls, Texas

National Association of Manufacturers - New York, New York

National Research Council - Washington, D. C.

North Texas State College - Denton, Texas

Oklahoma Corporation Commission - Oklahoma City, Oklahoma

Oklahoma State Department of Health - Oklahoma City, Oklahoma

Oklahoma State Geological Survey - Norman, Oklahoma

Oklahoma Water Resources Board - Oklahoma City, Oklahoma

Red River Compact Commission

Socony Mobile Oil Co., Inc. - Augusta, Kansas

Texas Bureau of Economic Geology - Austin, Texas

Texas Fish and Game Commission - Wichita Falls, Texas

Texas Railroad Commission - Oil and Gas Division - Austin, Texas

Texas State Board of Water Engineers - Austin, Texas

Texas State Department of Health - Austin, Texas

United States Department of Commerce

Weather Bureau - Fort Worth, Texas

United States Department of Defense

Department of the Army

Army Artillery & Missile Center - Ft. Sill, Oklahoma

Corps of Engineers - Dallas, Texas

Tulsa, Oklahoma

United States Department of the Interior

Bureau of Reclamation

Denver, Colorado

Oklahoma City, Oklahoma

Pueblo, Colorado

Geological Survey - Water Resources Division

Branch of Ground Water

Albuquerque, New Mexico

Norman, Oklahoma

Branch of Quality of Water

Austin, Texas

Fayetteville, Arkansas

Oklahoma City, Oklahoma

Branch of Surface Water

Austin, Texas

Ft. Smith, Arkansas

Oklahoma City, Oklahoma

Topeka, Kansas

Wichita Falls, Texas

University of Kansas - Lawrence, Kansas

University of Missouri - Columbia, Missouri

University of Oklahoma - Norman, Oklahoma

Wichita County Water Improvement

Districts No. 1 and 2 - Wichita Falls, Texas

Wichita Health Unit - Wichita Falls, Texas

APPENDIX II

CONTINUOUS SAMPLING STATIONS FROM WHICH
DATA HAVE BEEN COLLECTED, CALCULATED AND EVALUATED

RED RIVER BASIN

CONTINUOUS SAMPLING STATIONS WITH CORRESPONDING DISCHARGE READINGS

1945-1956 Water Years

No.	Station Number	Station	No. of Yrs. Discharge Data	No. of Yrs. Quality Data
1	700	Beaver Creek near Waurika, Oklahoma	3	1
2	500	Cache Creek at Walters, Oklahoma	18	2
3	526	Clear Boggy Creek near Caney, Oklahoma	15	1
4	501	Deep Red Run near Randlett, Oklahoma	7	1 + 8 Mo.
5	701	East Cache Creek near Elgin, Oklahoma	2	1
6	489	Elk Creek near Hobart, Oklahoma	7	2
7	528	Kiamichi River near Belzoni, Oklahoma	32	7
8	504	Little Beaver Creek near Duncan, Oklahoma	8	2
9	535	Little River near Horatio, Arkansas	27	3
10	531	(1) Little River near Idabel, Oklahoma	19	7
11	725	Little Washita River near Ninnekah, Okla.	5	1
12	506	Little Wichita near Archer City, Texas	24	2 + 10 Mo.
13	704	Little Wichita near Henrietta, Texas	4	2 + 10 Mo.
14	533	Mountain Fork near Eagletown, Oklahoma	30	1
15	524	Muddy Boggy near Farris, Oklahoma	19	1
16	479	Mulberry Creek at Brice, Texas	3	1 + 10 Mo.
17	478	Prairie Dog Town Fork of Red River Near Brice, Texas	10	1 + 10 Mo.
18	513	Pond Creek near Ft. Cobb, Oklahoma	16	1 + 10 Mo.
19	495	Quitaque Creek near Quitaque, Texas	11	0 + 2 Mo.
20	712	(2) Red River at Fulton, Arkansas	30	5

No.	Station Number	Station	No. of Yrs. Discharge Data	No. of Yrs. Quality Data
21	508	Red River at Gainesville, Texas	21	5 + 7 Mo.
22	522	Red River at Denison Dam near Denison, Tex.	34	12
23	552	Red River near Shreveport, Louisiana	29	1
24	724	Rush Creek near Maysville, Oklahoma	3	1
25	517	Rush Creek near Purdy, Oklahoma	14	3
26	481	Salt Fork Red River near Mangum, Oklahoma	1	2
27	703	Salt Fork Red River near Wellington, Texas	5	2 + 4 Mo
28	543	Sulphur River at Darden, Texas	32	2 + 4 Mo.
29	512	Washita River at Carnegie, Oklahoma	20	3
30	520	Washita River near Durwood, Oklahoma	29	9 + 10 Mo.
31	515	Washita River near Tabler, Oklahoma	13	6
			509	95 + 1 Mo.

CONTINUOUS SAMPLING STATIONS WITHOUT CORRESPONDING DISCHARGE READINGS

	721	Washita River near Foss, Oklahoma	-	2

(1) NOTE: Quality samples were taken at old station above Lukfata Creek during water years 1948 and 1949. All discharge readings, and all quality samples since water year 1949 have been taken at station below Lukfata Creek. This station is sometimes referred to as "Little River below Lukfata Creek near Idabel, Oklahoma."

(2) NOTE: Prior to 1950 gaging station located at Garland, Arkansas.

CONTINUOUS SAMPLING STATIONS FROM WHICH
DATA HAVE BEEN COLLECTED, CALCULATED AND EVALUATED

ARKANSAS RIVER BASIN

CONTINUOUS SAMPLING STATIONS WITH CORRESPONDING DISCHARGE READINGS

1945-1956 Water Years

No.	Station Number	Station	No. of Yrs. Discharge Data	No. of Yrs. Quality Data
1	228	Arkansas River at Arkansas City, Kansas	41	5
2	408	Arkansas River at Dardanelle, Arkansas	20	8
3	418	Arkansas River at Little Rock, Arkansas	30	11
4	238	Arkansas River at Ralston, Oklahoma	31	6 + 9 Mo.
5	259	Arkansas River at Tulsa, Oklahoma	31	9 + 9 Mo.
6	403	Arkansas River at Van Buren, Oklahoma	30	11
7	389	Bell Cow Creek at Chandler, Oklahoma	8	1
8	281	Bird Creek near Sperry, Oklahoma	19	2
9	362	Canadian River at Amarillo, Texas	19	6
10	364	Canadian River at Bridgeport, Oklahoma	13	8
11	352	Canadian River near Sanchez, N. M.	21	3 + 9 Mo.
12	713	(1) Canadian River at Tascosa, Texas	0	5 + 4 Mo.
13	392	Canadian River at Whitefield, Oklahoma	19	10 + 3 Mo.
14	716	Chikaskia River near Corbin, Kansas	7	1 + 1 Mo.
15	258	(2) Cimarron River at Mannford, Oklahoma	13	1
16	246	Cimarron River at Mocane, Oklahoma	15	2
17	257	Cimarron at Oilton, Oklahoma	12	0 + 3 Mo.
18	253	Cimarron River at Perkins, Oklahoma	18	4
19	330	Cimarron River (of Canadian) at Ute Park, New Mexico	45	5

No.	Station Number	Station	No. of Yrs. Discharge Data	No. of Yrs. Quality Data
20	247	Crooked Creek near Nye, Kansas	15	0 + 10 Mo.
21	390	Deep Fork River at Beggs, Oklahoma	19	4 + 11 Mo.
22	391	(3) Deep Fork River at Dewar, Oklahoma	14	2
23	302	Elk River near Tiff City, Missouri	18	2
24	314	Illinois River at Tenkiller Res. near Gore, Oklahoma	20	4 + 3 Mo.
25	710	Little River near Norman, Oklahoma (below Hog Creek)	5	3
26	723	Little River near Norman, Oklahoma	5	2
27	367	Little River at Sasakwa, Oklahoma	15	1
28	295	Neosho* River near Commerce, Oklahoma	18	7
29	310	Neosho* River at Fort Gibson Res. (near Fort Gibson, Oklahoma)	7	5
30	305	Neosho* River near Langley, Oklahoma	18	4 + 1 Mo.
31	309	Neosho* River at Waggoner, Oklahoma	13	3
32	226	Ninnescah River at Peck, Kansas	19	0 + 6 Mo.
33	383	North Canadian near Canton, Oklahoma (at Canton Res.)	20	3 + 3 Mo.
34	384	(4) North Canadian near El Reno, Oklahoma	27	4
35	388	North Canadian at Wetunka, Oklahoma	20	3
36	714	North Fork Ninnescah near Cheyney, Kansas	7	1
37	413	Petit Jean Creek at Danville, Arkansas	41	4
38	711	Poteau River at Wister Res. near Wister, Okla.	19	1 + 8 Mo.
39	231	Salt Fork at Alva, Oklahoma	14	1
40	235	Salt Fork near Jet, Oklahoma	20	0 + 8 Mo.
41	252	Skeleton Creek near Lovell, Oklahoma	8	5
42	715	South Fork Ninnescah near Murdock, Kansas	7	1
43	300	Spring River near Quawpaw, Oklahoma	18	2

No.	Station Number	Station	No. of Yrs. Discharge Data	No. of Yrs. Quality Data
44	249	Turkey Creek near Drumond, Oklahoma	10	1
45	359	Ute Creek near Buyeros, New Mexico	6	3 + 8 Mo.
46	360	Ute Creek near Logan, New Mexico	21	1
47	278	Verdigris River near Claremore, Oklahoma	22	7
48	283	Verdigris River at Inola, Oklahoma	13	9
49	270	Verdigris River at Lenapah, Oklahoma	19	5
			870	194
		CONTINUOUS SAMPLING STATIONS WITHOUT CORRESPONDING DISCHARGE READINGS		
1	719	Arkansas River at Bixby, Oklahoma	--	1
2	718	Arkansas River at Kaw City, Oklahoma	--	3
3	720	Arkansas River at Webbers Falls, Oklahoma	--	1
4	709	Canadian River at Borger, Texas	--	1
5	722	Fourche La Fave River near Alpin, Arkansas	--	1
6	307	(5) Neosho* River near Choteau, Oklahoma	--	1
				8

(1) NOTE: Discharge readings at Amarillo used for Tascosa quality station.

(2) NOTE: Quality data without corresponding discharge readings are available at this station for an additional two years.

(3) NOTE: Quality data without corresponding discharge readings are available at this station for one additional year.

(4) NOTE: Quality samples were taken at Yukon, Oklahoma during water years 1953 and 1954 and at El Reno, Oklahoma during water years 1955 and 1956. Discharge readings taken at El Reno during entire period.

(5) NOTE: Discharge data available at this station for 13 years prior to period of quality data but not during this period.

* NOTE: This river known as the "Neosho" in Kansas and "Grand" in Oklahoma. It is referred to as the Neosho in both States in this and other listings since the station descriptions were taken from publications which generally followed this procedure.

APPENDIX III

EXPLANATION OF TERMINOLOGY USED IN DATA SUMMARY SHEETS

Station Number: Number designation for station given in U. S. G. S. Water Supply Paper 1311 from numbers 1 - 612. Above Station No. 612 they were designated arbitrarily by this office.

Discharge: Average annual or monthly discharge of the station in cubic feet per second.

Number of Days: Number of days in the month or year during which discharge and quality data were available.

Weighted Average - ppm: The annual or monthly average concentration in parts per million of the mineral constituent concerned adjusted to corresponding discharge.

Weighted Average - T/D: The annual or monthly average quantity of the appropriate mineral constituent in tons per day adjusted to corresponding discharge.

Max. - ppm: The maximum concentration in parts per million of the appropriate mineral constituent which was recorded as the result of the analysis of one composite sample during the month or year.

Min. - ppm: The minimum concentration in parts per million of the appropriate mineral constituent which was recorded as the result of the analysis of one composite sample during the month or year.

Weighted Data Avg.: The annual average concentration or quantities of the various mineral constituents adjusted to discharge, the maximum and minimum values of these constituents, the average discharge, and the total number of days for all data available during a particular water year. These figures may not represent the entire water year.

Wtd. Wtr. Yr. Ave.: The annual average discharge for the entire water year regardless of the amount of quality data available during the water year and the number of days in the entire water year (365 or 366).

Water Year: A period of time lasting twelve months beginning October 1 of one year and ending September 30 of the year designated as the water year. For example, Water Year 1955-56 begins October 1, 1955 and ends September 30, 1956.

NOTE: All results shown in Appendix III are summarized from published and unpublished U. S. Geological Survey records. Water Year 1955-56 data subject to revision.

DATA SUMMARY SHEET

Station Description: Arkansas River near Tulsa, Oklahoma

Station Number: 259 | River Basin: Arkansas | Tributary: Main Stem

Date		Discharge	No. of Days	Sulfates				Chlorides				Dissolved Solids			
				Weighted Average		Max.	Min.	Weighted Average		Max.	Min.	Weighted Average		Max.	Min.
Yr.	Month	cfs		ppm	tons/day	ppm	ppm	ppm	tons/day	ppm	ppm	ppm	tons/day	ppm	ppm
1946	10	2060	31	193	1070	380	126	1700	9380	5030	990	3020	17200	5360	1970
	11	3700	30	197	1970	340	85	1070	1070	1540	680	2140	21400	2970	1420
	12	2210	31	364	2160	385	331	1390	8270	1530	1290	2940	17500	3160	2780
1947	1	1720	31	312	1450	336	273	1670	7770	1840	1450	3360	15600	3670	2930
	2	1420	28	382	1460	388	365	1550	5910	1580	1480	3230	12400	3280	3120
	3	5200	31	273	3820	349	181	1290	18000	1600	955	2780	39000	3260	1920
	4	34900	30	99	9270	300	42	453	42600	1360	248	990	93200	2770	570
	5	24200	31	157	10300	250	94	418	27400	820	170	1030	67300	1840	511
	6	11800	30	207	6560	253	137	459	14500	530	360	1180	37300	1360	904
	7	7240	31	170	3330	350	75	346	6760	835	215	1010	18900	1550	809
	8	1820	31	315	1540	416	220	780	3820	955	345	1830	8940	2100	980
	9	931	30	254	637	267	233	1430	3590	1440	1420	2790	7020	2800	2790
	Wtd. Data Avg.	8100	365	166	3630	416	42	604	13200	5030	170	1350	29500	5360	511
	Wtd.Wtr.Yr.Avg	8100	365												
1947	10	577	31	247	384	267	240	1740	2710	1920	1570	3300	5120	3590	3040
	11	674	30	199	362	202	195	1740	3180	1800	1680	3270	5940	3370	3160
	12	1450	31	224	874	229	218	1620	6350	1720	1540	3160	12300	3340	2980
1948	1	1230	5	226	748	--	--	1660	5500	--	--	3130	10400	--	--
	2	1330	29	188	674	276	178	1320	4740	2100	1240	2600	9350	4000	2460
	3	9080	31	178	4360	182	175	1060	26100	1100	1040	2120	51900	2200	2060
	4	3790	30	246	2520	249	244	896	9170	905	890	1940	19900	1960	1930
	5	3400	31	214	1970	233	199	940	8670	960	890	1970	18100	2000	1920
	6	12900	30	68	2300	72	67	271	9390	275	270	707	24600	708	694
	7	34100	31	87	8000	89	84	350	32200	360	330	855	78500	860	848
	8	18100	31	145	7050	193	88	520	25300	660	215	1180	57600	1450	556
	9	3650	30	222	2190	224	221	930	9140	930	925	1980	19500	1980	1970
	Wtd. Data Avg.	8060	340	128	2780	276	67	572	12500	2100	215	1260	27500	4000	556
	Wtd.Wtr.Yr.Avg	7560	365												

NOTE: See table at beginning of Appendix III for explanation of terminology used on this sheet.

DATA SUMMARY SHEET

Station Description: Arkansas River near Tulsa, Oklahoma

Station Number: 259 | River Basin: Arkansas | Tributary: Main Stem

Date		Discharge	No. of Days	Sulfates				Chlorides				Dissolved Solids			
				Weighted Average		Max.	Min.	Weighted Average		Max.	Min.	Weighted Average		Max.	Min.
Yr.	Month	cfs		ppm	tons/day	ppm	ppm	ppm	tons/day	ppm	ppm	ppm	tons/day	ppm	ppm
1948	10	1690	31	192	874	195	189	1250	5670	1380	1170	2460	11200	2660	2340
	11	4560	30	221	2720	225	208	1350	16600	1450	1160	2720	33400	2860	2420
	12	3510	31	286	2710	321	259	1620	15300	1720	1420	3160	29900	3230	2970
1949	1	2490	14	318	2140	327	315	1450	9740	1450	1450	3020	20300	3040	3010
	2	29700	28	83	6700	128	70	394	31500	662	325	857	68700	1350	732
	3	12800	31	192	6590	225	168	726	25000	745	710	1620	55800	1730	1540
	4	9200	30	149	3810	224	99	408	10400	695	255	1030	26400	1600	704
	5	39100	31	127	13400	222	66	367	38500	775	135	905	95200	1720	442
	6	26500	30	195	13900	290	142	443	31800	625	335	1140	81300	1460	878
	7	8710	31	246	5790	321	176	604	14100	860	350	1460	34400	2020	932
	8	4730	31	235	3010	260	160	760	9700	920	530	1710	21900	1970	1200
	9	10100	30	196	5360	247	135	630	17100	1000	360	1450	39300	2110	937
	Wtd. Data Avg.	13100	348	162	5740	327	66	539	19100	1720	135	1240	44100	3230	442
	Wtd. Wtr.Yr.Avg.	13500	365												
1950	1	2640	31	318	2270	342	300	1370	9740	1480	1300	2890	20600	3060	2780
	2	2430	28	328	2150	394	258	1170	7660	1460	830	257	16800	2950	1910
	3	2180	31	329	1940	380	295	1180	6980	2150	1020	2560	15100	4070	2370
	4	1690	30	264	1200	284	190	1330	6040	1390	840	2490	11400	2830	1760
	5	6140	31	154	2560	265	93	624	10300	1360	295	1380	22900	2730	806
	6	5640	30	130	1980	326	68	604	9200	1620	268	1310	20100	3240	711
	7	19000	31	86	4400	182	18	388	19800	1620	55	886	45200	3020	232
	8	32900	31	95	8420	195	68	387	34200	795	315	935	82700	1740	762
	9	10300	30	172	4780	266	134	503	13900	670	395	1220	34000	1600	991
	Wtd. Data Avg.	9320	273	132	3320	394	18	524	13200	2150	55	1190	30100	4070	232
	Wtd.Wtr.Yr.Avg.	7740	365												

NOTE: See table at beginning of Appendix III for explanation of terminology used on this sheet.

DATA SUMMARY SHEET

Station Description: Arkansas River near Tulsa, Oklahoma

Station Number: 259 | River Basin: Arkansas | Tributary: Main Stem

Date		Discharge	No. of Days	Sulfates				Chlorides				Dissolved Solids			
				Weighted Average		Max.	Min.	Weighted Average		Max.	Min.	Weighted Average		Max.	Min.
Yr.	Month	cfs		ppm	tons/day	ppm	ppm	ppm	tons/day	ppm	ppm	ppm	tons/day	ppm	ppm
1950	10	4630	31	248	3090	310	164	689	8590	845	505	1730	21600	2060	1250
	11	2430	30	298	1950	309	276	1040	6770	1160	940	2390	15600	2560	2230
	12	2240	31	319	1930	341	305	1200	7250	1380	1150	2670	16200	2950	2570
1951	1	2240	31	319	1920	365	303	1310	7890	1550	1260	2880	17400	3360	2770
	2	3650	28	267	2630	365	192	1210	11900	1590	835	2580	25500	3400	1870
	3	3440	31	321	2990	349	291	1260	11700	1580	1120	2840	26300	3320	2510
	4	4280	30	251	2900	300	133	1220	14100	1360	635	2580	29800	3430	1420
	5	42900	31	120	13700	214	42	440	50900	1740	168	1090	126000	3530	471
	6	37700	30	150	15000	267	84	344	34900	660	178	945	96000	1800	503
	7	56700	31	98	15000	172	53	198	30200	365	112	613	93600	1140	379
	8	8160	31	194	4260	219	161	520	11400	700	445	1440	31600	1740	1260
	9	18100	30	100	4900	184	32	354	17300	685	198	875	42700	1600	509
	Wtd. Data Avg.	15600	365	139	5880	365	32	422	17800	1740	112	1070	45300	3530	379
	Wtd.Wtr.Yr.Avg.	15600	365												
1951	10	6700	31	149	2690	171	105	491	8880	850	372	1230	22300	1880	922
	11	8080	30	171	3730	196	134	727	15900	905	565	1670	36400	1940	1270
	12	4590	31	231	2860	256	204	735	9090	865	635	1800	22300	2110	1560
1952	1	4430	31	268	3200	308	235	907	10800	1160	820	2160	25800	2520	2060
	2	3840	29	292	3030	305	266	898	9310	920	870	2210	22900	2240	2170
	3	10500	31	140	4000	210	75	650	18600	995	300	1500	43000	2140	761
	4	9220	30	214	5320	258	101	877	21800	1220	630	1950	49500	2600	1400
	5	7650	31	256	5280	323	132	770	15900	1180	410	1850	38100	2640	1080
	6	6640	30	150	2640	299	74	483	8650	865	268	1190	21300	2060	675
	7	1480	31	205	814	219	165	994	3960	1180	670	2170	8640	2390	1400
	8	1410	31	179	679	230	137	1060	4000	1780	660	2220	8420	3440	1400
	9	691	30	208	388	279	175	1430	2660	1690	1160	2860	5330	3460	2370
	Wtd. Data Avg.	5440	366	197	2900	323	74	734	10800	1780	268	1730	25400	3460	761
	Wtd.Wtr.Yr.Avg.	5440	366												

NOTE: See table at beginning of Appendix III for explanation of terminology used on this sheet.

DATA SUMMARY SHEET

Station Description: Arkansas River near Tulsa, Oklahoma

Station Number: 259 | **River Basin:** Arkansas | **Tributary:** Main Stem

Date		Discharge	No. of Days	Sulfates				Chlorides				Dissolved Solids			
				Weighted Average		Max.	Min.	Weighted Average		Max.	Min.	Weighted Average		Max.	Min.
Yr.	Month	cfs		ppm	tons/day	ppm	ppm	ppm	tons/day	ppm	ppm	ppm	tons/day	ppm	ppm
1952	10	378	31	193	197	197	189	1340	1370	1380	1290	2790	2850	2870	2690
	11	637	29	178	306	194	161	149	2560	1850	1180	3050	5250	3940	2560
	12	940	31	189	478	204	172	1250	3180	1410	1140	2580	6530	2960	2290
1953	1	1110	31	237	706	258	208	1560	4660	1750	1360	3150	9390	3470	2720
	2	1190	28	260	838	276	243	1500	5000	1850	1400	3120	10100	3680	2880
	3	2520	31	177	1210	239	96	1090	7400	1780	745	2400	16400	3510	1610
	4	2830	30	119	910	214	55	886	6770	1340	520	1800	13800	2650	1070
	5	2800	31	137	1000	208	54	946	7150	1980	498	1970	14900	3930	1080
	6	2670	29	123	890	208	74	960	6960	2320	620	2020	14600	4660	1360
	7	4140	31	171	1900	304	20	1070	12000	2820	288	2210	24700	5380	646
	8	1900	31	166	849	296	110	1200	6150	2520	745	2340	12000	4930	1580
	9	716	30	159	308	194	143	1460	2820	2000	1220	2940	5670	3910	2580
	Wtd. Data Avg.	1830	363	163	805	304	20	1120	5520	2820	288	2300	11400	5380	646
	Wtd.Wtr.Yr.Avg	1820	365												
1953	10	500	31	142	190	260	90	1620	2180	3510	740	3240	4380	7250	1520
	11	1430	30	94	360	173	43	914	3520	1850	410	1880	7230	3650	898
	12	1340	31	146	525	195	85	1310	4720	1850	680	2600	9350	3480	1440
1954	1	762	31	229	469	368	208	2020	4140	3390	1750	4030	8260	6580	3520
	2	856	28	236	543	257	211	1810	4180	2220	1220	3620	8330	4290	2540
	3	845	31	242	551	262	196	1650	3750	1920	1100	3380	7690	3850	2390
	4	906	30	200	489	254	59	1430	3480	2000	810	3020	7350	4050	1620
	5	5120	31	169	2330	260	34	1050	14500	1800	285	2140	29500	3520	682
	6	2810	30	213	1610	275	117	1640	12400	2080	925	3270	24700	4170	1870
	7	416	31	182	206	226	122	1570	1770	2050	1240	3060	3430	4060	2470
	8	196	31	159	84	179	147	1700	898	2820	1200	3290	1740	5240	2380
	9	157	30	223	94	225	95	2480	1040	5960	1250	4750	2000	10900	2620
	Wtd. Data Avg	1280	365	180	622	368	34	1360	4710	5960	285	2740	9500	10900	682
	Wtd.Wtr.Yr.Avg	1280	365												

NOTE: See table at beginning of Appendix III for explanation of terminology used on this sheet.

DATA SUMMARY SHEET

Station Description: Arkansas River near Tulsa, Oklahoma

Station Number: 259 | River Basin: Arkansas | Tributary: Main Stem

Date		Discharge	No. of Days	Sulfates				Chlorides				Dissolved Solids			
				Weighted Average		Max.	Min.	Weighted Average		Max.	Min.	Weighted Average		Max.	Min.
Yr.	Month	cfs		ppm	tons/day	ppm	ppm	ppm	tons/day	ppm	ppm	ppm	tons/day	ppm	ppm
1954	10	271	31	123	90	157	107	1400	1020	1950	1050	2530	1840	3670	2180
	11	240	30	138	89	159	91	1640	1060	1950	1120	3400	2200	3930	2240
	12	243	31	139	91	171	119	2160	1420	3100	1900	4060	2680	5590	3720
1955	1	392	31	161	170	170	151	2150	2280	2800	1850	4170	4400	5250	3630
	2	522	28	185	261	202	164	1900	2670	2200	1780	3720	5250	4290	3540
	3	651	31	170	298	214	87	1530	2700	2250	550	3060	5370	4260	1170
	4	544	30	220	324	411	145	2010	2950	5120	1180	4020	5900	9600	2440
	5	17000	31	141	6480	184	83	890	40500	2000	270	1850	84700	3780	701
	6	13400	30	148	5350	237	108	600	21700	1080	320	1380	50200	2350	863
	7	3710	31	204	2040	241	149	960	9610	1400	550	2060	20600	2880	1290
	8	1050	31	189	530	228	63	143	4050	1800	560	2850	8040	3540	1200
	9	529	30	245	349	299	203	2340	3330	3140	1880	4580	6540	6080	3740
	Wtd. Data Avg.	3230	365	155	1350	411	63	901	7830	3140	270	1910	16600	9600	701
	Wtd. Wtr. Yr. Avg.	3230	365												
1955	10	14900	31	51	2040	209	23	214	8580	2800	105	646	25700	5360	312
	11	935	30	190	481	199	181	1250	3150	1320	1150	2580	6520	2770	2360
	12	703	31	208	395	215	202	1410	2680	1450	1390	2930	5560	3000	2890
1956	1	712	31	232	445	267	211	1560	3000	1900	1400	3180	6120	3710	2870
	2	971	29	231	604	279	212	1670	4360	1800	1300	3390	8870	3670	2740
	3	781	31	280	589	300	258	1930	4080	2020	1650	3500	7390	3980	3360
	4	761	30	241	495	258	216	1510	3110	1880	1180	3100	6380	3770	2540
	5	720	31	202	493	234	137	1580	3080	3340	850	3220	6240	6560	1900
	6	897	30	185	448	275	100	1190	2890	2850	660	2440	5920	5600	1380
	7	908	31	214	525	365	101	1600	3920	3240	550	3190	7830	6120	1230
	8	261	31	294	207	421	239	2140	1510	5370	1720	4280	3010	10100	3510
	9	89	30	416	100	528	265	2920	703	3690	2000	5660	1310	7180	3980
	Wtd. Data Avg.	1900	366	110	564	528	23	670	3440	5370	105	1480	7630	10100	312
	Wtd. Wtr. Yr. Avg.	1900	366												

NOTE: See table at beginning of Appendix III for explanation of terminology used on this sheet.

DATA SUMMARY SHEET

Station Description: Red River near Gainesville, Texas

Station Number: 508 | River Basin: Red | Tributary: Main Stem

Date		Discharge	No. of Days	Sulfates				Chlorides				Dissolved Solids			
				Weighted Average		Max.	Min.	Weighted Average		Max.	Min.	Weighted Average		Max.	Min.
Yr.	Month	cfs		ppm	tons/day	ppm	ppm	ppm	tons/day	ppm	ppm	ppm	tons/day	ppm	ppm
1944	5	1070	31	292	850	471	170	668	1920	1060	392	1620	4620	2490	973
	6	4270	30	409	4710	659	181	571	6580	1030	252	1610	18500	2710	757
	7	859	31	736	1700	1140	442	1136	2710	1650	635	2970	6360	4380	1740
	8	566	31	535	815	782	434	805	1230	1300	620	2140	3280	3280	1710
	9	577	30	516	811	940	253	975	1520	2070	398	2400	3740	4790	1080
	Wtd. Data Avg.	1460	153	446	1760	1140	170	700	2760	2070	252	1860	7360	4790	757
	Wtd.Wtr.Yr.Avg.	1150	366												
1944	10	2870	31	162	1280	495	113	298	2330	1080	243	823	6760	2540	633
	11	1030	30	236	655	639	149	599	1660	1500	348	1360	3760	3440	956
	12	1040	31	511	1430	683	138	1170	3290	1530	445	2760	7710	3600	1010
1945	1	1120	31	466	1370	751	296	116	3410	1740	740	2600	7620	4040	1720
	2	2230	28	224	1340	616	91	567	3410	1550	240	1400	8420	3530	702
	3	13700	31	84	3110	172	42	217	7960	496	104	602	22300	1140	362
	4	11000	30	123	3660	244	50	190	5650	500	65	669	19900	1330	360
	5	2470	31	230	1580	386	136	500	3340	785	325	1280	8560	1970	828
	6	4040	30	200	2180	383	79	344	3720	840	195	949	10200	2040	525
	7	5010	31	263	3550	353	152	412	5580	572	265	1140	15400	1550	732
	8	1700	31	358	1640	836	139	575	2630	1630	269	1570	7210	3960	836
	9	3950	30	102	1090	570	31	220	2340	1110	62	619	6610	2720	250
	Wtd. Data Avg.	4190	365	168	1910	836	31	333	3780	1740	62	919	10400	4040	250
	Wtd.Wtr.Yr.Avg.	4190	365												
1945	10	11300	31	67	2050	293	31	157	4810	730	62	465	14200	1740	250
	11	564	29	334	507	380	308	823	1250	895	780	1970	3000	2170	1860
	12	486	31	394	515	446	349	919	1200	960	875	2220	2940	2400	2100
1946	1	2910	31	166	1310	521	58	451	3540	1440	168	1130	9530	3290	491
	2	3100	28	142	1180	398	53	361	3010	1100	147	963	8030	2540	452
	3	1470	31	190	755	338	74	511	2030	912	202	1300	5160	2140	654
	4	910	29	296	730	497	180	810	1990	1240	520	1900	4680	2880	1250
	Wtd. Data Avg.	2980	210	124	1000	521	31	315	2540	1440	62	829	6670	3290	250
	Wtd.Wtr.Yr.Avg.	2510	365												

NOTE: See table at beginning of Appendix III for explanation of terminology used on this sheet.

DATA SUMMARY SHEET

Station Description: Red River near Gainesville, Texas

Station Number: 508 | River Basin: Red | Tributary: Main Stem

Date		Discharge	No. of Days	Sulfates				Chlorides				Dissolved Solids			
				Weighted Average		Max.	Min.	Weighted Average		Max.	Min.	Weighted Average		Max.	Min.
Yr.	Month	cfs		ppm	tons/day	ppm	ppm	ppm	tons/day	ppm	ppm	ppm	tons/day	ppm	ppm
1952	10	119	31	705	226	709	697	1490	480	1520	1450	3670	1180	3710	3610
	11	142	30	577	221	650	491	1280	490	1440	1090	3110	1190	3500	2650
	12	179	31	449	216	484	369	1110	534	1220	935	2670	1280	2900	2270
1953	1	126	31	579	196	646	398	1380	468	1580	1010	3320	1130	3710	2460
	2	151	28	559	227	657	392	1240	504	1440	885	2740	1110	3500	2220
	3	804	31	206	446	637	109	459	994	1360	200	1250	2700	3470	637
	4	1050	30	419	1180	1190	48	865	2440	2750	105	2320	6550	6480	394
	5	754	31	278	567	845	94	594	1210	1780	208	1550	3170	4230	619
	6	1160	30	175	550	670	111	360	1140	1740	192	1010	3180	4220	614
	7	1630	31	388	1700	655	42	472	2070	1050	101	1470	6470	2470	342
	8	1410	31	713	2710	799	446	920	3490	1110	550	2730	10300	3100	1860
	9	243	30	611	400	754	415	973	637	1450	800	2670	1740	3670	2050
	Wtd. Data Avg.	651	365	412	725	1190	42	689	1210	2750	101	1910	3360	6480	342
	Wtd. Wtr. Yr. Avg.	651	365												
1953	10	8040	31	223	4820	803	109	321	6970	1450	150	955	20700	3670	501
	11	2460	30	243	1600	705	106	465	3060	1420	238	1220	8030	3560	666
	12	1110	31	273	813	525	105	574	1710	1030	222	1280	3820	2630	368
1954	1	365	31	561	553	578	537	1160	1140	1200	1090	2940	2900	3060	2770
	2	263	28	621	440	626	610	1260	890	1290	1260	3180	2250	3300	3100
	3	204	31	540	296	547	526	1190	654	1200	1180	2850	1560	2870	2820
	4	1080	30	349	1010	586	142	719	2090	1420	330	1880	4850	3440	886
	5	17800	31	189	9100	385	67	278	13300	565	114	873	41800	1650	412
	6	4610	30	350	4350	680	152	536	6670	985	210	1530	19000	2650	736
	7	379	31	624	636	664	557	1220	1250	1280	1150	3030	3090	3080	2910
	8	237	31	490	312	1190	436	1290	824	2000	1000	3180	2020	5210	2390
	9	196	30	1000	526	1140	575	1690	891	1700	1280	3820	2010	4720	3090
	Wtd. Data Avg.	3090	365	246	2050	1190	70	396	3310	2000	114	1130	9450	5210	412
	Wtd. Wtr. Yr. Avg.	3090	365												

NOTE: See table at beginning of Appendix III for explanation of terminology used on this sheet.

DATA SUMMARY SHEET

Station Description: Red River near Gainesville, Texas

Station Number: 508 | River Basin: Red | Tributary: Main Stem

Date		Discharge	No. of Days	Sulfates				Chlorides				Dissolved Solids			
				Weighted Average		Max.	Min.	Weighted Average		Max.	Min.	Weighted Average		Max.	Min.
Yr.	Month	cfs		ppm	tons/day	ppm	ppm	ppm	tons/day	ppm	ppm	ppm	tons/day	ppm	ppm
1954	10	181	31	451	220	474	228	929	453	1020	530	2290	1120	2490	1270
	11	137	30	436	160	497	353	926	341	1020	750	2370	874	2620	1940
	12	181	31	384	187	500	215	875	433	1080	525	2240	1090	2720	1360
1955	1	200	31	403	218	441	325	1090	586	1200	900	2700	1460	3040	2150
	2	245	28	338	224	491	208	898	595	1200	532	2160	1430	2910	1330
	3	437	31	187	221	407	72	482	567	1200	242	1210	1430	3100	603
	4	248	30	288	192	466	127	685	458	1100	280	1760	1180	2850	831
	5	11400	31	232	9040	601	128	324	12600	1350	170	1010	39100	3300	622
	6	10000	30	401	10900	733	210	515	13900	925	350	1580	42700	2830	1020
	7	1770	31	705	3360	814	302	1070	5100	1310	630	2940	14000	3560	1610
	8	731	31	705	1390	900	363	1190	2340	1400	790	3180	6260	3830	1960
	9	2860	30	125	962	596	70	229	1770	1200	118	670	5170	3000	400
	Wtd. Data Avg.	2630	365	318	2260	900	70	461	3280	1400	118	1360	9690	3830	400
	Wtd. Wtr. Yr. Avg.	2630	365												
1955	10	15800	31	177	7510	472	128	240	10200	800	162	775	33000	2170	590
	11	1410	30	545	2070	642	509	922	3510	1250	805	2510	9550	3280	2230
	12	620	31	656	1100	681	630	1340	2240	1380	1300	3380	5660	3530	3240
1956	1	472	31	688	875	703	662	1420	1820	1500	1380	3620	4600	3690	3510
	2	544	29	765	1120	798	577	1630	2380	1800	1222	4060	5950	4430	3110
	3	297	31	798	640	835	747	1710	1370	1780	1600	4230	3390	4370	3990
	4	256	30	762	484	714	676	1500	1040	1600	1380	3840	2650	4030	3490
	5	3300	31	454	4050	780	170	710	6300	1300	360	2010	17900	3390	975
	6	2150	30	820	4740	1120	479	1050	6040	2250	560	3070	17800	5490	1760
	7	734	31	465	918	1050	57	815	1620	1900	155	2170	4290	4860	446
	8	185	31	763	380	770	745	1400	700	1450	1340	3560	1770	3620	3470
	9	108	30	720	210	742	659	1330	387	1420	1180	3480	1020	3640	3080
	Wtd. Data Avg.	2180	366	345	2030	1120	57	533	3140	2250	155	1530	8990	5490	446
	Wtd. Wtr. Yr. Avg.	2180	366												

NOTE: See table at beginning of Appendix III for explanation of terminology used on this sheet.